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SUPERNUMERARY CHROMOSOMES IN A POPULATION OF *TRADESCANTIA EDWARDSIANA*

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ABSTRACT. From cytological examination of 1,293 root tip cells and microsporocytes from 51 plants of *Tradescantia edwardsiana*, it was determined that supernumerary chromosomes varied in number among cells of a plant, among plants of a population, and among the subpopulations. The supernumeraries are visible at interphase as heteropycnotic masses. During mitosis and usually during meiosis they stain the same as normal chromosomes. In occasional cells, elongate, lightly stained, possibly heteropycnotic supernumeraries were seen. It was concluded that the supernumeraries are of recent origin; they are slightly detrimental to plants possessing them, and such plants are restricted to "superior" sites, in this case, disturbed soil.

The term "supernumerary" is applied to a distinctive kind of chromosome that is present, in addition to the normal $2n$ number, in the cells of some plants and animals. The term does not apply to an extra normal chromosome as in a trisomic. Rather, the chromosome must be more or less completely genetically inert so that there are essentially no phenotypic nor habitat differences between plants without and those with one or a few supernumeraries. Supernumerary chromosomes do not synapse with normal chromosomes at meiosis although there may be a loose association between them. Furthermore, they are not present in all individuals nor all populations of the taxon. Beyond these three criteria there are no characteristics common to all supernumerary chromosomes; even the characters of genetic inertness and pairing are relative.

Other terms that have been applied to supernumerary chromosomes imply something restrictive. "Accessory" implies additional usefulness and, therefore, function, such as sex chromosomes of animals. "B-chromosomes" must be heteropycnotic at some stage of mitosis, meiosis, or during interphase. "Fragment" chromsomes must have originated by fragmentation of a normal chromosome. The term "inert" should be applied to chromosomes carrying absolutely no genes, a condition difficult to prove. All such types of "extra" chromosomes exist and the term supernumerary includes them all. The "m" chromosomes of mosses, formerly considered to be supernumerary, are now

believed to be regular, though unusual, members of the set for the particular species (Bryan, 1955).

Supernumerary chromosomes have been reported in numerous species of angiosperms. In a recent survey (Parker, 1959) discussed them for 199 species belonging to 88 genera, in 29 families, of both monocots and dicots. They occur in taxa having normal chromosomes that are quite small (e.g., *Clarkia* and *Oenothera*) as well as in taxa with large normal chromosomes (e.g., *Lilium* and *Tradescantia*).

All investigators of supernumerary chromosomes in species of the virginiana group of *Tradescantia* have reported the supernumerary chromosomes as being much smaller than the normal chromosomes, about ⅙ or less as long and with the same or somewhat smaller diameter. Both terminal (Whitaker, 1936; Swanson, 1940) and non-terminal (Darlington, 1929; Swanson, 1943) centromeres have been claimed for supernumeraries of *Tradescantia*. It has been claimed generally that they are not heterochromatic, although Riley (1958) considered those studied by him in *T. paludosa* to be heterochromatic. A few reports of meiotic synapsis between supernumerary and normal chromosomes have been made (Darlington, 1929, 1937; Giles, 1941) whereas Whitaker (1936) and Riley (1958) saw no such synapsis. Swanson (1941, 1943) claimed to have detected regular association between supernumeraries and particular regions of certain normal chromosomes during pollen tube mitosis.

There are a number of possible ways of accounting for the conflicting claims for supernumerary chromosomes in *Tradescantia*. There may be more than one type of supernumerary in this group of species. Supernumeraries may behave differently when present in large numbers than when only one or two are present in a cell. If there is only one type, then it must vary in form, staining reaction, and association with normal chromosomes among cells of a plant, plants of a species, or species of the genus. However, Swanson (1943) considered them to be structurally similar throughout the genus and Whitaker (1936) considered all those studied by him in *T. paludosa* to be homologous.

In the virginiana group of *Tradescantia* supernumerary chromosomes have been reported in all species that have been examined extensively enough (Anderson and Diehl, 1932; Anderson and Sax, 1936; Celarier, 1956) but they are uncommon. Anderson (1954), in a report on the cytological examination of 485 plants from 230 populations of 18 species of this group, found supernumerary chromosomes in only 10 plants and these from 8 different states.

Within a population of individuals possessing supernumerary chromosomes they are apt to occur in a large percentage of individuals.

Riley (1958) reported supernumerary chromosomes in three populations of *T. paludosa*. Plants having supernumerary chromosomes constituted 54, 20, and 53 per cent of each population. Among 14 local population samples of *Allium cernuum*, Grun (1959) reported percentages of plants containing supernumerary chromosomes from 0 to 48. Among 9 populations of *Lilium medeoloides* (Samejima, 1958), 3 did not have supernumeraries. Among the 177 plants examined, from the 9 populations, 108 had no supernumeraries. One particular population was sampled extensively but plants with and plants without supernumeraries were scattered at random; there was no correlation with habitat types.

Lewis (1951) reported 27% of a 324-plant sample of *Clarkia elegans*, collected throughout the range of the species, to have from 1 to 6 supernumerary chromosomes. Further sampling of the 142 plants along a 7.5 mile transect indicated that 31% of plants had supernumeraries. No particular center of distribution was found. Plants containing supernumeraries were either randomly distributed or there were many local centers of concentration. He found no correlation between presence or absence of supernumeraries and morphological characters, sun or shade sites, nor early or late flowering.

Supernumerary chromosomes in the grass, *Festuca pratensis*, were present in 20.4% of 2,606 Swedish plants examined, in 4.4% of 1,654 English plants (in 11 of 47 populations), and in 5.6% of 108 plants from Holland (Bosemark, 1954). In Sweden there was a correlation between clay soils and a relatively high percentage of plants with supernumerary chromosomes, clay soils being the most favorable soil type for the species. In English material there was no correlation between frequency of accessories and population size, soil type, humidity, nor influence of cultivation. It was noted, however, that old populations lacked supernumeraries whereas the few populations with high frequencies were all young.

MATERIALS AND METHODS. This study consisted of a cytological examination of 51 plants of *Tradescantia edwardsiana* from a small area about 4 miles north of Austin on Dry Creek. Three sub-populations were sampled; no plants of the species occurred between the sub-populations. The sample of sub-population A consisted of 38 plants which were growing in loose soil on a slope at the foot of a cliff south of the creek. The sample of population B consisted of 7 plants on compact undisturbed soil about 150 feet from population A and north of the creek. The sample of sub-population C consisted of 6 plants 250 feet west of sub-population A, south of the creek, in loose undisturbed soil. All three sub-populations were under trees. Plants growing in re-

cently disturbed soil in the western half of population A are designated A′; those of the eastern half in undisturbed soil as A″. The plants of A′ and A″ formed a continuous population about 50 feet long by 15 feet wide. Plants in A″ were more widely scattered and fewer than in A′. The A′ site was a dirt pile outside a cave once occupied by Indians and recently disturbed by archeologists. Edaphically it was somewhat different from the A″ site.

Pollen mother cells (P.M.C's) were squashed in aceto-carmine; root tips in aceto-orcein. Observations were made by the author and eleven graduate students. The author saw many of the cells from which data were taken. Most material, buds and root tips, were taken from the plants in their original site. Later studies were made from many of the same plants growing in the greenhouse. All data for each plant were pooled. Unusual cytological conditions were noted only at the last examination of root tips. These apparently vigorously growing root tips were taken from potted plants in the greenhouse, late in their season of activity, and when the roots examined were growing between the soil and pot. Data from this last examination were not included.

OBSERVATIONS AND DISCUSSION. Tables 1 and 2 present the numerical data on supernumerary chromosomes from the three sub-populations. In addition to numbers, certain characteristics of the supernumerary chromosomes were noted.

The supernumerary chromosomes were always much smaller than the normal chromosomes. At metaphase of mitosis they were about the same width but about 1/7 the length of the normal chromosomes (Fig. 1). At meiosis they took two forms, spherical or elongate. The sperical ones were only slightly narrower than the normal chromosomes and about ⅕ their length (Fig. 2). The elongate forms of the supernumeraries at first meiotic metaphase and anaphase were about ½ as long but about ⅙ as wide as the normal chromosomes (Fig. 3).

During the phases of mitosis the supernumerary chromosomes always stained the same as the regular chromosomes (Fig. 1). During meiosis they usually stained the same as regular chromosomes, but in occasional cells at metaphase and early anaphase, lightly-stained supernumerary chromosomes were observed. These latter were usually thin and elongate (Fig. 3) whereas most supernumeraries at metaphase and anaphase were spherical (Fig. 2). The elongate lightly-stained supernumeraries were either bivalents with nearly terminal chiasmata or univalents. Whether the narrow lightly-stained end of a normal univalent (Fig. 3) is an attached supernumerary or a modified end of a normal chromosome is not known. The lighter staining of

TABLE 1

Number of cells with various numbers of supernumerary chromosomes during mitosis.

Plant No.	Number of Supernumeraries 0	1	2	3	4	5	6	7	8	9	*Supernumeraries* total per plant	av. No. per cell
Subpopulation A′												
59–2	43	9	5	5	8	3	8	1	2	1	161	1.9
59–3	1	1	2	1	1	..	..	..	..	..	12	2.0
59–4	27	2	..	..	..	..	..	..	..	..	2	.07
59–5	....	3	4	3	..	..	..	..	..	..	20	2.0
59–6	2	..	7	1	8	..	..	..	..	..	49	2.7
59–8	4	2	..	..	..	..	..	..	..	..	2	.33
59–9	7	..	5	1	1	1	..	..	..	..	22	1.5
59–10	12	..	2	3	..	..	..	..	..	..	13	.77
59–20	9	5	4	2	..	..	..	..	..	..	19	.95
8 plants	66	..	..	..	..	..	..	..	..	..	.....	.....
Subpopulation A″												
59–16	69	6	..	..	..	..	..	..	..	..	6	.08
7 plants	91	..	..	..	..	..	..	..	..	..	.....	.....
Subpopulation B (no plants examined for mitosis)												
Subpopulation C												
59–25	.....	2	8	..	..	..	..	..	..	..	18	1.8
Totals	331	30	37	6	18	4	8	1	2	1	324	1.11

438 cells

these elongate supernumeraries may have been produced by the elongation process and the resulting reduced diameter, and may not represent heteropycnosis. The spherical supernumeraries were usually as darkly stained as the normal chromosomes, were associated with one or two others, were single, or were associated with a normal chromosome. These associations were possibly the result of synapsis; they may also have been the result of secondary associations or due to stickiness. In this material, true synapsis between supernumerary and regular chromosomes was uncommon or non-existent.

The elongate, lightly-stained bivalents or univalents appeared heteropycnotic, that is, they appeared less darkly stained than the normal chromosome. True heteropycnosis of the supernumeraries was revealed during interphase of root tip nuclei. During that phase the supernumeraries were easily counted as darkly-stained bodies of nearly the same size as during mitosis (Fig. 4). They were never found in interphase nuclei of plants known to have no supernumeraries. They correspond in numbers to the numbers of supernumeraries present during mitosis in cells of the same root tip preparation. It is

TABLE 2

Numbers of cells with various numbers of supernumerary chromosomes during meiosis.

Plant No.	0	1	2	3	4	5	6	7	9	*Supernumeraries* total per plant	av. No. per cell	Per cell av. No. mitosis	av. No. mitosis & meiosis
Subpopulation A′													
59–2	.....	15	12	12	7	6	2	..	..	145	2.7	1.9	2.3
59–3	2	8	16	14	1	..	..	..	..	86	2.1	2.0	2.1
59–4	1	.....	2	10	1	..	4	1	2	78	3.7	.07	1.88
59–5	1	1	2	....	..	..	1	..	..	11	2.2	2.00	2.1
59–6	1	.....	1	....	..	3	1	..	..	23	3.8	2.7	3.3
59–8	1	3	8	7	3	..	..	..	..	52	2.36	.33	1.35
59–9	.....	.....	4	....	..	..	..	..	..	8	2.0	1.5	1.75
59–20	3	.....	4	6	..	..	..	..	..	26	2.0	.95	1.48
59–22	5	30	....	....	..	..	..	..	..	30	0.86	.....	.....
59–27	.....	2	1	1	..	5	..	..	..	32	3.55	.....	.....
59–28	4	.....	4	..	1	..	..	..	..	12	1.33	.....	.....
59–29	4	16	6	6	..	..	..	..	..	46	1.44	.....	.....
59–31	.....	.....	....	2	..	..	6	..	..	42	5.2	.....	.....
59–32	.....	5	....	....	..	..	..	..	..	5	1.0	.....	.....
59–34	16	23	....	....	..	..	..	..	..	23	0.6	.....	.....
59–37	.....	30	....	....	..	..	..	..	..	30	1.0	.....	.....
59–38	.....	3	2	....	..	..	..	..	..	7	1.4	.....	.....
59–39	2	19	3	1	..	..	..	..	..	28	1.12	.....	.....
8 plants	135	.....	....	....	..	..	..	..	..	.....	.....	.....	.....
Subpopulation A″													
59–16	25	.....	....	....	..	..	..	..	..	.....	.....	.....	.....
7 plants	44	.....	....	....	..	..	..	..	..	.....	.....	.08	.....
Subpopulation B													
7 plants	142	.....	....	....	..	..	..	..	..	.....	.....	.....	.....
Subpopulation C													
59–25	9	25	....	1	5	6	14	..	..	162	2.7	1.8	2.25
5 plants	72	.....	....	....	..	..	..	..	..	.....	.....	.....	.....
Totals	467	180	65	60	18	20	28	1	2	846	2.00	1.11	1.63

855 cells

Grand Totals—1,293 cells examined

concluded that the supernumerary chromosomes of *T. edwardsiana* are heteropycnotic as Riley (1958) concluded for *T. paludosa.*

The supernumeraries are probably different among themselves in morphology and in behavior. In figure 1 at the center of the figure there is a metaphase supernumerary possessing a long sub-terminal centromeric constriction. None of the others in this figure have visible constrictions. At the lower left of the same figure there is an associated pair of supernumeraries. The other three supernumeraries of the figure are

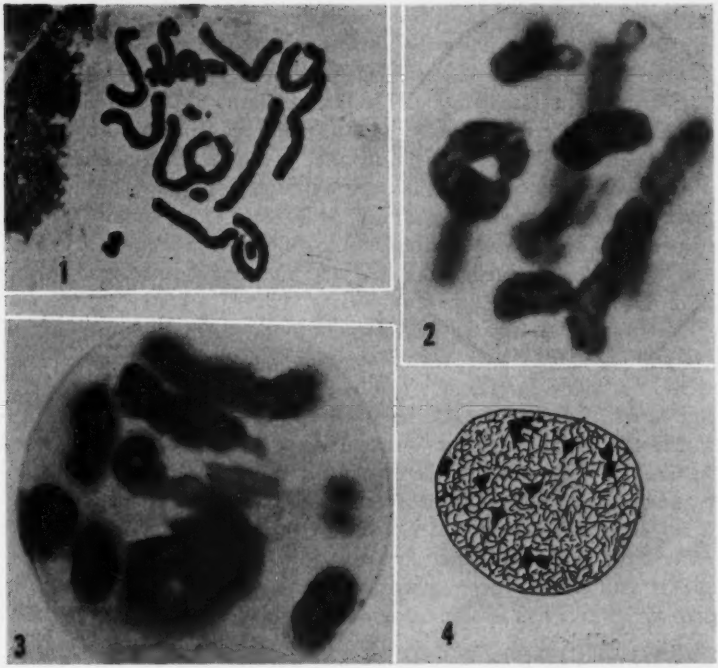

Fig. 1–4. Supernumerary and normal chromosomes in *Tradescantia edwardsiana*. Fig. 1. Root tip squash showing metaphase of mitosis with 6 supernumerary and 12 normal chromosomes. Two supernumeraries intimately associated in lower left of figure. A supernumerary with a satellite at center of figure. The other three supernumeraries possibly associated with normal chromosomes. Fig. 2. Early anaphase of the first meiotic division in microsporocyte, two supernumeraries associated with normal anaphase chromosomes in upper part of figure. Fig. 3. Metaphase I in microsporocyte. At center are two elongate, lightly-stained supernumeraries, the lower a bivalent. Just above these is a normal chromosome with a tip resembling the supernumeraries below. At right of figure are two paried spherical supernumeraries (out of focus). Fig. 4. Camera lucida drawing of the nucleus of a root tip cell during interphase, showing the heteropycnotic supernumeraries.

without visible constrictions and are not associated with other supernumeraries although they may be loosely associated with normal chromosomes. In figure 2 there are two spherical supernumeraries that are associated with normal chromosomes. In figure 3 there are both long and thin as well as spherical supernumeraries. The latter are rather out of focus in the figure. These are not associated with normal chromosomes.

As clearly indicated by the data in tables 1 and 2, the number of supernumerary chromosomes varied from plant to plant and, within

a plant having them, from cell to cell. The maximum number found in one cell was 9. Usually the number was 6 or lower. This was true both in root tip cells and in P.M.C.'s. Riley (1958) reported a similar variation in numbers among P.M.C.'s of plants of *T. paludosa* from three populations. Whitaker (1936) reported a constant number throughout the life cycle in plants of *T. paludosa*. Darlington (1929) also reported near constancy of supernumeraries in plants of *T. virginiana*, *T. crassifolia*, and *T. humilis*. Anderson (1954) found 10 plants of 6 species to have only 2 supernumerary chromosomes each. Constancy of number during the life cycle may be characteristic only of plants with one or two supernumeraries.

Among the plants having supernumerary chromosomes in the populations studied here, the average number per microsporocyte was exactly 2 (table 2). The average based upon root tip mitosis was 1.1, but fewer plants were examined for mitosis than meiosis, and it is much more dificult to count supernumeraries at metaphase of mitosis in most preparations than at first meiosis in P.M.C.'s. Therefore, the average of 1.63 for both mitosis and meiosis is probably too low. Since 2 supernumeraries per cell has been reported in so many plants by other cytologists, and since an average of about 2 characterizes the plants that have supernumeraries in this population, it seems that 1 or 2 per cell has less adverse effect upon the host plants or that 1 or 2 per cell is most stable in mitosis and meiosis. The average number of supernumeraries per cell in the 50 plants of *T. paludosa* having supernumeraries reported by Riley (1958) seems to be 1–2 supernumeraries per cell also.

No plants with supernumerary chromosomes were found in subpopulation B. In sub-population C only one plant (*59–25*) had supernumerary chromosomes (table 1). In population A most of the plants with supernumeraries were in area A′ in which 21 of 30 plants had them. In the adjacent area A″ only 1 of 8 plants had supernumeraries. Furthermore, Anderson (1954) examined 17 plants of this same species from two other populations near Austin and found none with supernumeraries. It can be concluded that, as in other species of the *virginiana* group, supernumerary chromosomes are not widespread in *T. edwardsiana* but are restricted to localized populations or subpopulations.

Such a distribution of populations containing supernumerary chromosomes could indicate either that supernumeraries have been a characteristic feature of the *virginiana* group for a very long time but limited to certain populations by presently unknown factors, or else that supernumerary chromosomes arise sporadically from time to

time. There is no previous evidence in any species of *Tradescantia* that plants containing supernumerary chromosomes are restricted by ecological conditions. Except in the grass, *Festuca pratensis*, there is no evidence that plants of any species containing supernumerary chromosomes are restricted by ecological conditions. There is also no evidence that, within a species, supernumerary chromosomes are limited to particular genotypes.

For the population studied here, the fact that supernumeraries were not present in plants of sub-populations B and C, except for one plant, and were not more common in area A″, requires consideration. The proposed explanation involves certain aspects of the origin of such chromosomes. At the present time there is no clear evidence of the origin of supernumerary chromosomes in any plant or species known to have them except in rye (Muntzing, 1948). There are many hypotheses, however, and it is not to be expected that all supernumeraries have arisen in the same manner. All proposals, except that of Riley, have derived them from normal chromosomes. In *Tradescantia*, Darlington, (1929) proposed fragmentation of a normal chromosome anywhere along its length followed by the acquisition of a centromere. Whitaker (1936) proposed the loss of most of the two arms of a chromosome, the remaining centromere, and short proximal portions of the two arms constituting a supernumerary chromosome. Swanson (1943), however, proposed that they originated from normal chromosomes by the loss of whole arms, except the distal and proximal portions, by overlapping inversions and reciprocal translocations. Riley (1958) has offered a novel proposal for the origin of supernumeraries in *Tradescantia*. He suggested that they represent a few remaining small chromosomes from some tropical form of *Tradescantia*, such as *T. fluminensis* that does have small chromosomes, following a cross between such a form and, perhaps, *T. ohiensis*. Later, following loss of genetic material, hybridizations spread such supernumerary chromosomes to other species. This proposal assumes a rather unlikely cross and assumes a single, one-event, origin for all supernumerary chromosomes in the *virginiana* group.

The existing evidence indicates, on the other hand, that supernumeraries in *Tradesdantia* have had sporadic origins in many species of the group. They are present in only a very few populations of any one species (Anderson, 1954) yet have been reported in all species. They are found throughout the geographical range of the *virginiana* group. In populations where they occur they are present in up to 50% of the plants, which indicates that they are not particularly harmful to plants possessing them. Yet within the population reported here

plants with supernumeraries are nearly all restricted to one part of one of three sub-populations. Since the species is characterized by self-sterility and is insect pollinated, and since the subpopulations are probably within the range of visitations of individual insects, one would expect the supernumeraries to have reached an equilibrium throughout the whole population if they had been present since the establishment of this population. It is likely, however, that the supernumeraries have originated quite recently within the A′ group of plants and have hardly spread even into the contiguous but somewhat dissimilar area occupied by the A″ sub-population. Such a spontaneous origin would require either derivation from a normal chromosome or from some other source. No one, except Riley, has yet proposed that any type of supernumerary chromosome has an origin other than from a normal chromosome. There is no indication from the present study of the source or mode of origin of the supernumerary chromosomes observed.

Since most of the *T. edwardsiana* plants containing supernumerary chromosomes grew in disturbed soil (the whole A′ population and No. 59–25 of population C which, unlike the others, grew on the highway embankment), it is possible that there is some relationship between the type of site and plants having supernumerary chromosomes. As Bosemark (1954) found for *Festuca pratensis*, the plants containing supernumerary chromosomes grew in the best site (disturbed soil is probably superior to undisturbed for *T. edwardsiana*). Plants growing in the A′ region were the most vigorous-appearing of all those studied. Also, as in *F. pratensis*, there may be a correlation between presence of supernumeraries and young populations. It is likely that the disturbed site has been recently occupied by *T. edwardsiana* and therefore the A′ population has had a relatively recent origin, and likewise, that the supernumerary chromosomes are of recent origin, either induced by or permitted to persist by the disturbed site. In what appear to be older populations, on undisturbed soils, plants having supernumerary chromosomes were not found. It is therefore postulated that supernumerary chromosomes in *T. edwardsiana* are slightly deleterious to plants possessing them, so that plants growing in sites barely adequate for normal plants cannot survive if they have supernumeraries.

Additional indication that plants with supernumeraries are not as vigorous as those without them was evident during the resumption of growth in pots in the greenhouse in the fall. All of the 24 plants had been given the same treatment and conditions from time of trans-

planting to the greenhouse in April of 1959 to November 9, 1959, when data for table 3 were collected.

On November 9 the potted plants were arranged according to general size and vigor from the most vigorous (No. 59–23) to the least (No. 59–9). Of the 13 plants that had no supernumeraries, 10 were included among the 11 (46 per cent) most vigorous; whereas 10 of the 11 plants having supernumeraries were included in the 13 (54 per cent) least vigorous plants. Plant 59–22 that was the 6th most vigorous was unusual among plants having supernumeraries in that it had no more than one in any cell.

It should be noted, however, that in their natural habitats the A′ plants were the most vigorous or at least as vigorous as those from other sites, presumably because of superior edaphic conditions. In the greenhouse, however, where all plants were under identical environmental conditions, plants with supernumeraries were definitely less vigorous than those not possessing them.

Similar reduction in vigor of plants possessing a very small number of supernumerary chromosomes has been reported in *Festuca pratensis* (Bosemark, 1957). In most species, however, reduction in vigor sets in only when the number of supernumeraries becomes high.

The conclusions discussed above apply only to this population of *T. edwardsiana*. In no sense should they be interpreted as applying to any other species of plant. They do not apply even to *T. paludosa* since Riley (1958) found supernumerary chromosomes in two populations that were growing in completely undisturbed sites. Of course,

TABLE 3

Arrangement of 24 potted plants in order from most to least vigorous

Plant No.	Supernumeraries Have	Have not	Plant No.	Supernumeraries Have	Have not
59–23	.....	x	59–9	0–4	..
59–13	.....	x	59–17	.....	x
59–1	.....	x	59–5	0–6	..
59–24	.....	x	59–3	0–4	..
59–21	.....		59–20	0–3	..
59–22	0–1	..	59–4	0–9	..
59–7	.....	x	59–15	.....	x
59–18	.....	x	59–2	0–6	..
59–19	.....	x	59–16	0–1	..
59–11	.....	x	59–10	0–3	..
59–14	.....	x	59–12	.....	x
59–6	0–6	..	59–9	0–5	..

if those sites were close to ideal for the species the conclusions for *T. edwardsiana* might still apply.

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THE SOUTHWESTERN NATURALIST 5 (2): 61–65 AUGUST 10, 1960

EGG PRODUCTION OF *STREPTOCEPHALUS SEALI* RYDER, WITH NOTES ON THE DISTINCTIONS BETWEEN CERTAIN NORTH AMERICAN STREPTOCEPHALIDS

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ABSTRACT. The egg production of *Streptocephalus seali* Ryder, a common North American fairy shrimp, is reported. This large production, which is twice that of the only other recorded species, is perhaps a factor in the wide distribution of the species. A new distinction between *S. seali* and *Streptocephalus texanus* Packard is described and illustrated.

EGG PRODUCTION

METHOD: *Streptocephalus seali*, the "spiny tailed fairy shrimp," was selected for several reasons. It is a species easily obtained during most seasons of the year in the vicinity of New Orleans. It is also the most widespread of North American fairy shrimps, having been collected from 23 states, Canada, and Mexico.

All species used during the study were collected from a roadside ditch at Florenville in St. Tammany Parish, Louisiana. This ditch is temporary in nature, had a predominantly mud bottom lined on both sides with vegetation, and an average depth of one and one-half feet. Two separate collections were made: one on June 30, 1957, and another on November 30, 1957. The shrimp were obtained with a dip net, and transported to the laboratory in water taken from the ditch at the time of collection. They were maintained in this water until used.

For egg production studies, one female and one male were isolated together in original ditch water in a 400 ml beaker. The specimens were fed once every two days with a yeast suspension made from ordinary baker's yeast, as recommended by Moore (1957). Egg production commenced at varying times following isolation. The eggs, being heavier than water, sank to the bottom after deposition, where they could be counted. After each count, the eggs were removed from the beaker. The results of these counts are given in Table 1.

[1] This paper represents a portion of a thesis submitted to the Graduate faculty of the Department of Biological Sciences, Loyola University, in partial fulfilment of the requirements for the degree of Master of Science.

TABLE 1

Egg Laying Data on Streptocephalus seali

Date Isolated	Age	Counts												Total	Date of Death
		Date	No.	Date	No.	Date	No.	Date	No.	Date	No.	Date	No.		
7/1*	M	7/18	91	7/22	64	7/27	123	8/2	115	8/10	94	8/15	1	488	8/22
7/10*	I	7/20	13	7/22	11	7/25	48	7/27	20	8/2	51	8/5	7	150	8/10
7/10*	I	7/20	23	7/22	35	7/25	8	7/27	1	8/5	1	.....	..	67	8/15
7/1	M	7/4	120	7/7	133	7/10	6	7/20	1	7/27	2	.....	..	262	7/29
12/1	I	12/9	41	12/11	134	12/15	33	12/18	16	.....	....	.....	..	224	12/25
12/1	I	12/9	64	12/11	72	12/15	16	12/18	26	.....	....	.....	..	178	12/25
7/25	M	8/2	19	8/5	15	8/22	45	8/26	3	.....	....	.....	..	82	9/10
7/10*	I	7/20	26	7/22	21	7/25	17	7/27	20	.....	....	.....	..	84	8/10
7/25*	M	8/2	29	8/5	37	8/10	1	.....	.....	.....	....	.....	..	67	8/26
7/1*	I	7/4	16	7/10	28	7/18	3	.....	.....	.....	....	.....	..	47	7/25
7/1*	I	7/10	6	7/14	1	7/18	18	.....	.....	.....	....	.....	..	25	7/22
12/1	I	12/11	52	12/15	24	.....	.....	.....	.....	.....	....	.....	..	76	12/21
12/1	I	12/9	24	12/11	4	.....	.....	.....	.....	.....	....	.....	..	28	12/21
12/1	I	12/9	56	12/11	86	.....	.....	.....	.....	.....	....	.....	..	142	12/18
12/1	I	12/9	75	12/11	38	.....	.....	.....	.....	.....	....	.....	..	115	12/21
12/1	I	12/9	35	12/11	51	.....	.....	.....	.....	.....	....	.....	..	86	12/15
7/1*	I	7/4	24	7/7	9	.....	.....	.....	.....	.....	....	.....	..	33	7/10
12/1	I	12/9	72	.....	.....	.....	.....	.....	.....	.....	....	.....	..	72	12/18
12/1	I	12/11	54	.....	.....	.....	.....	.....	.....	.....	....	.....	..	54	12/15
7/25	M	7/29	8	.....	.....	.....	.....	.....	.....	.....	....	.....	..	8	8/5
7/25*	M	7/27	18	.....	.....	.....	.....	.....	.....	.....	....	.....	..	18	8/2
7/25*	M	8/10	23	.....	.....	.....	.....	.....	.....	.....	....	.....	..	23	9/5
8/10	M	8/15	20	.....	.....	.....	.....	.....	.....	.....	....	.....	..	20	9/2
7/10	I	7/18	19	.....	.....	.....	.....	.....	.....	.....	....	.....	..	19	7/20
7/10	I	7/27	3	.....	.....	.....	.....	.....	.....	.....	....	.....	..	3	8/5
7/1*	M	7/4	64	.....	.....	.....	.....	.....	.....	.....	....	.....	..	64	7/7

* Isolated in constant temp. (25°C.). All others isolated at room temperature.
I Immature when isolated.
M Mature when isolated.

RESULTS. Of a total of 39 females isolated as described, 26 produced and deposited eggs, 10 did not, and the data on three were discarded for various reasons. The greatest number of eggs deposited by a single female was 488 over a period of 46 days. Two other females deposited totals of 262 and 224 eggs in 27 and 18 days, respectively. Four other females deposited over 100 eggs each. The average number of eggs laid by *S. seali* during this experiment was 93.6 per female. These results contrast strikingly with those reported by Avery (1940) for *Eubranchipus vernalis* in the only other published study on fairy shrimp egg production. The greatest total noted in Avery's experiment was 95 eggs by one female and the average was 41.7 per female, less than half of the *S. seali* average reported here.

DISCUSSION. Of the shrimp used in this experiment, some were isolated as mature animals, others as immature (Table 1, second column). The production of eggs by those isolated when mature should not be considered as total, since there was a possibility of deposition of eggs before collection. The production of those individuals isolated when immature can be considered as total.

Egg production in the natural habitat may be even greater than that recorded here. The author has collected mature females with over 300 eggs in their egg sacs, and it is not uncommon to collect females carrying over 200 eggs. If the egg sac empties and refills several times during the egg producing period, as observation of isolated pairs would indicate, this suggests tremendous potential egg production.

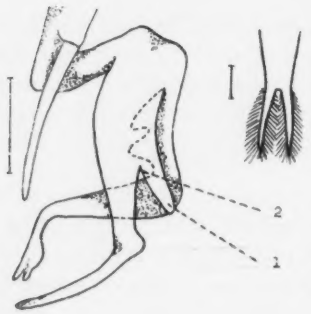
DISTINCTIONS BETWEEN SPECIES OF STREPTOCEPHALUS

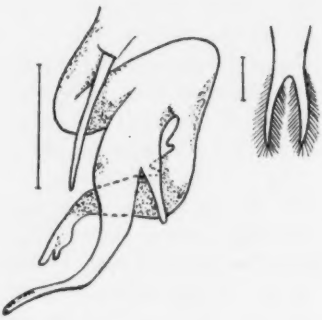
Of the 28 known species of the genus *Streptocephalus*, five occur in North America: *S. seali* Ryder, *S. similis* Baird, *S. antillensis* Mattox, *S. dorothae* Mackin, and *S. texanus* Packard. Adequate distinction of these five species exists in present literature and keys, with the exception of a clear differentiation between *S. seali* and *S. texanus*, particularly in the sub-adult stages.

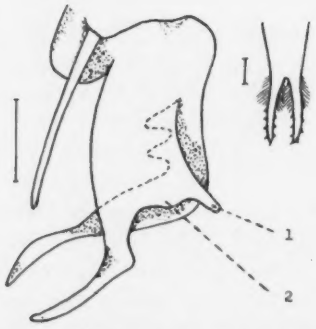
Streptocephalus seali and *S. texanus* inhabit the midwestern plains states and have been reported occasionally as a dual population (Dexter, 1953; Leonard and Ponder, 1949). When such dual populations exist, it is sometimes difficult to identify these two species with certainty on the basis employed in most keys; i.e., the structure of the cercopods of the male. In *S. seali* these appendages, fringed with setae during juvenile stages, became spined distally after maturity. On the other hand, the cercopods of *S. texanus* remain setiferous throughout life. Hence a distinction based on this morphological difference would

necessitate obtaining mature animals possessing fully developed cercopods.

A new distinction was noted in the highly specialized second antennae of male specimens of *S. seali* and *S. texanus*. The distal ends of these antennae form what is commonly referred to as the "scissors." The outer branch of the scissors exhibits a posterior spur or tooth (Figure 1, 1; Figure 2, 1). On *S. texanus*, the inner margin of this spur forms a very sharp angle (Figure 1, 2) with the inner margin of the branch. On *S. seali*, the inner margin of this spur does not form a sharp angle with the inner margin of the branch, but is more or less continuous with it, forming a characteristic "hump" (Figure 2, 2).







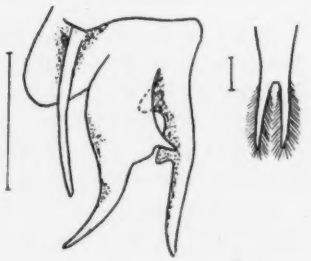


Figure 1. S. *texanus* ♂, 16.5 mm. Second antenna and cercopods. Note: Scale lengths used in Figures 1–4 represent 1 mm.

Figure 2. S. *seali* ♂, 18 mm. Second antenna and cercopods.

Figure 3. S. *texanus* ♂, 8 mm. Second antenna and cercopods.

Figure 4. S. *seali* ♂, 16 mm. Second antenna and cercopods.

This is a distinction which can be used before the animals reach maturity (Figures 3 and 4).

In addition to the many specimens of *S. seali* collected by the writer from the Florenville ditches a number of collections in the Loyola University museum have been critically studied. These include 12 lots, numbering from a few to several hundred individuals, collected from the vicinity of Alton, St. Tammany Parish, Louisiana, during the years 1951–1953; two collections from Mississippi; and one each from Oklahoma and Kansas. Six collections of *S. texanus* from Gillespie County, Texas, also have been examined.

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NOTES ON LATE CENOZOIC HYLID AND LEPTODACTYLID FROGS FROM KANSAS, OKLAHOMA AND TEXAS

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ABSTRACT. *Syrrhophus* sp. is reported from Knox County, Texas; *Pseudacris* cf. *triseriata* from Meade County, Kansas and Beaver County, Oklahoma; and *Acris* cf. *gryllus* from Meade County, Kansas. The relation of these finds to late Cenozoic climatic conditions is discussed.

The specimens reported below are in the collections of the University of Michigan Museum of Paleontology and the University of Kansas Museum of Vertebrate Paleontology and are, to the best of my knowledge, the only Pliocene and Pleistocene specimens of these families in the extensive collections of these institutions from the late Cenozoic of the Great Plains. I wish to thank Claude W. Hibbard and Robert Wilson, of the Michigan and Kansas Museums respectively, for the opportunity to examine these specimens. Certain of the Pleistocene specimens in the Michigan collection have been collected and made available for study through a National Science Foundation Grant, No. 5635, to C. W. Hibbard.

SYRRHOPHUS cf. MARNOCKI. A single ilium (UMMVP 39796) from the Seymour formation of Knox County, Texas, is so similar in size and form to the ilium of *Syrrhophus marnocki* that I have little hesitation in referring it to the genus *Syrrhophus* (see Figs. 1, 2). Specific identification is not feasible on the basis of this one specimen, but there is nothing morphologically inconsistent with reference to the species *marnocki*, and this reference seems likely on the basis of geographic and temporal considerations. The fauna with which it is associated is thought to be roughly contemporaneous with the Cudahy Fauna of Meade County, Kansas (Hibbard, in litt.), and is thus probably referable to the Kansan glacial period (Hibbard et al, 1958). Dr. Hibbard has informed me that many of the faunistic elements indicate a far more equable climate than existed for the more northern Cudahy fauna of that time.

PSEUDACRIS *cf.* TRISERIATA. Several small hylids are not as clearly distinguishable from each other on the basis of dissociated skeletal ele-

ments as might be wished. If, however, we postulate on ecologic, geographic and temporal grounds that Pleistocene specimens from southwestern Kansas most likely represent one of the three species living in or near that general area at the present time, then these three can be distinguished on the basis of certain elements. The ilium of *P. triseriata* has a broad subacetabular expansion, with extensive webbing between the expansion and the shaft; *Acris* has a very narrow subacetabular expansion, with virtually no webbing between the expansion and the shaft, and *P. clarki* is intermediate between these extremes (see Figs. 3–5). *Acris* is further distinguished by the frequent possession of a low but definite dorsal crest. The sacrum of both species of *Pseudacris* is of typical hylid form, with minor differences in proportions apparently existing between the two species; that of *Acris* has the diapophyses decidedly less expanded and, except for the procoelous condition, is somewhat reminiscent of the *Rana* sacrum. A related distinction can be noted in the coccyx; the coccygeal cotyles of *Pseudacris* are ovoid and confluent or closely approximated medially, whereas those of *Acris* are nearly round and distinctly separated from each other. Minor differences among the three forms with respect to proportions of the limb bones also seem to exist; these are, however, of a rather subtle nature, and are not accurately recognizable in all of the fossil specimens, particularly since these specimens are customarily incomplete.

None of the fossil specimens can be identified as *clarki*, although it is possible that some of the limb bones actually do represent that species. Specimens rather clearly referable to *P. triseriata* are as follows:

Cudahy Fauna—ten ilia, UMMVP 39598 and 39600. In addition to these ilia a number of limb bones in both the Kansas and Michigan collections seem on direct comparison to resemble those of Recent *triseriata* more closely than they do those of either *Acris* or *P. clarki*. The specimens are all from Meade County, Kansas, and, as was indicated above, are probably referable to the Kansan glacial period.

Doby Springs Fauna—one ilium, part of UMMVP 35826. This fauna is found from deposits in Beaver County, Oklahoma, and is thought to be Illinoian in age (Smith 1959).

Jinglebob Fauna—one ilium, UMMVP 35922. A few limb bones from this fauna are also tentatively referred to *triseriata*. Because of the somewhat fragmented condition of the ilium and the questionable accuracy of any identification based on limb bones, the occurrence of this species in the Jinglebob should be confirmed by the recovery of additional specimens before it is fully accepted. The fauna, also

from Meade County, Kansas, is of Sangamon age (Hibbard 1958 et al).

Cragin Quarry (?) *Fauna*—One coccyx, (UMMVP 41500) not identifiable to species, but referable at least to the genus *Pseudacris*, has been recovered from an unreported deposit (code name UM-K3-59) in Meade County. This deposit appears to be of Sangamon age and its recovered fauna suggests that it represents the Cragin Quarry Fauna (Hibbard, in litt.). In the absence of any definite record of *P. clarki* in Pleistocene deposits of this area, the specimen is tentatively referred to *P. triseriata*.

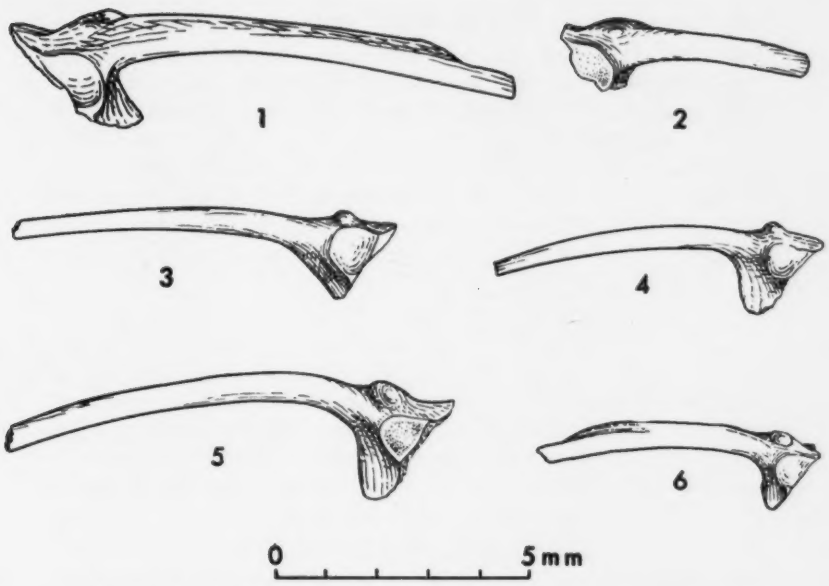
Jones Fauna—one ilium, KUMVP 5510 (part) and one sacrum (UMMVP 41478). In addition to these specimens, several coccyges and an atlas referable to the genus *Pseudacris* but not identifiable to species are present in the Kansas and Michigan collections. There are also a number of limb bones that appear fully consistent with identification as this form. This fauna, similarly from Meade County, is of late Wisconsin age.

Acris *cf.* gryllus. Three ilia (UMMVP 41339 and two uncatalogued) from the Wendell Fox Pasture locality of the Upper Pliocene Rexroad formation of Meade County are indistinguishable from the same element in Recent *Acris* (Fig. 6). In the absence of any indication to the contrary, the specimens are tentatively referred to the extant species. To the best of my knowledge these are the only hylid specimens that have been recovered from the Pliocene of this general area.

The only Pleistocene deposit that has yielded specimens definitely referable to *Acris* is that from which the Sangamonian Jinglebob fauna has been recognized. One ilium and coccyx can be referred to this genus with considerable assurance, and several limb bones appear more similar to *Acris* than to either of the species of *Pseudacris* now living in the area. Some of these specimens have been reported previously (Tihen 1954); re-examination confirms the propriety of the original reference to *Acris*.

REMARKS

For the most part the forms reported here are found in or near the same area today. The fossil record of *Syrrhophus* is appreciably north of the present known range of the genus, but not unreasonably so. The fauna with which it is associated also contains mammalian and avian elements whose present ranges reach their northern limit considerably south of Knox County. If this fauna is indeed contemporaneous with



Figures 1–6. Ilia of: (1) a Recent specimen of *Syrrhophus marnocki*; (2) UMMVP 39796, referred to *Syrrhophus*; (3) Recent *Pseudacris t. triseriata*; (4) Recent *Pseudacris clarki*; (5) Recent *Acris g. blanchardi*; (6) UMMVP 41339, referred to *Acris*. Drawings by Alice Boatright.

the Cudahy fauna from Kansas, a rather extreme climatic gradient must have existed at that time.

Negative evidence is highly unreliable, but it is nevertheless of interest to note that *Pseudacris triseriata*, except for a few specimens of somewhat questionable identification from Sangamon deposits, has appeared in Meade County deposits of glacial periods only. Since it reaches this area today, it can be expected to be found in interglacial periods also, but it would at least appear to have been much more common there during the glacial advances than during the warmer interglacial periods. Conversely, *Acris* has been identified only in the Rexroad and Jinglebob faunas, both of which are associated with relatively equable climatic conditions. At the present time Meade County is very near the periphery of the range of both forms; it seems likely that these ranges have fluctuated somewhat with the changing climatic conditions of the Pleistocene. The absence of *P. clarki* from the fossil record is not readily explainable except on the basis of failure to recover identifiable specimens.

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STATUS AND DISTRIBUTION OF THE RED FOX, (*VULPES VULPES*) IN OKLAHOMA*

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ABSTRACT. The red fox is established in the eastern half of Oklahoma. The Mississippi Valley fox, *Vulpes vulpes regalis* is found in the hilly regions of the State. The eastern fox, *V. v. fulva* is probably the form found in the Red River Valley. Considerable importation of red foxes into eastern Oklahoma is occurring.

The red fox (*Vulpes vulpes*) is native neither to the Southern Great Plains nor the Gulf Coast. In the Central United States it reaches its western limit in the prairie-grassland ecotone, which in Oklahoma occupies approximately the middle third of the state. This species is seemingly neither as common nor as widespread as the gray fox (*Urocyon cinereoargenteus*), whose range entirely overlaps that of the red fox in this area.

At present, published records give an incomplete picture of the distribution of this species in Oklahoma. Blair (1939) reported that the University of Michigan Museum of Zoology possessed a specimen from 12 miles north of Tahlequah, in Cherokee County, and noted that Marcy (1834) had reported one from the Red River Valley. McCarley (1952) recorded the species from two miles north of Colbert and nine miles west of Durant, Bryan County. To date these seem to be the only published records of red foxes in the State.

Churcher (1959 and pers. comm.) examined three Oklahoma specimens in his study of the red fox of North America. Two were specimens that we list below; the third was the University of Michigan specimen. In this paper he established the conspecificity of the red foxes of the old and new worlds, which accounts for our use of the combination *Vulpes vulpes* in this report.

The Oklahoma State University Museum contains nine specimens of red foxes from Oklahoma. Three are from the vicinity of Stillwater, Payne County; the remaining six are from separate localities, as follows: Tyner Creek north of Proctor, Adair County; State Route 68 south of Lake Holdenville Dam, Hughes County; Okmulgee County; U. S. Route 271, one mile north of Buzzard Creek, Pushmataha

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County; North Shore of Lake Texoma, one mile east of Willis, Marshall County; and near Bray, Stephens County.

The junior author has conducted a survey among the U. S. Fish and Wildlife Service trappers who work in the State of Oklahoma. Returns indicate that red foxes have been taken by predator control hunters in the following counties: Atoka, Bryan, Canadian, Cherokee, Choctaw, Comanche, Johnston, Latimer, Lincoln, McCurtain, Osage, Pawnee, Pittsburg, Pontotoc, Seminole, Stephens (specimen reported above), Wagoner and Woods Counties. The trappers also indicated that the animal was "rare" in Choctaw, Johnston, Lincoln, McCurtain, Osage, and Pawnee Counties. Negative responses were received from Alfalfa, Blaine, Custer, Dewey, Grady, Harper, McClain, Washita, and Woodward Counties.

The single fox reported from Woods County presents an enigma, for the surrounding counties are uniformly negative. Furthermore, Hall and Kelson (1958) indicate that in Kansas no red fox has been reported from west of the Arkansas River. However, Anderson and Nelson (1958) reported new records for the red fox in Kansas in Finney and Meade Counties, and the Junior author knows of one seen at Kirwin Dam in Phillips County, Kansas, on the Kirwin National Wildlife Refuge in July (?), 1959. These animals may have been imported by man, but the possibility exists that they represent extensions of range into the plains along major river systems.

Except for the Woods County specimen, no red foxes are known from the western counties of the state. Reports from the ecotone area indicate that the species occurs there only rarely. From the questionnaire returns there is no reason to believe that the animal is especially scarce in the eastern third of the state, particularly from the wooded or hilly portions. They are most numerous in the Ozark, Ouachita, and Osage Savanna Biotic Districts of Blair and Hubbell (1938). Extensions westward, as in Payne, Stephens, and Comanche Counties, are manifestations of a westward extension of suitable habitat.

Blair (1939) did not attempt to relate his Oklahoma specimen to any recognized subspecies. Hall and Kelson (1958) indicate that the red fox in Oklahoma and Kansas is referable to the subspecies *V. f. fulva*, (=*V. v. fulva*) and their map reflects the opinion that the Mississippi Valley fox, *V. v. regalis* occupies a range lying north of the Missouri River. Churcher, (pers. comm.), after extensive study of the red foxes of North America, assigned the foxes of the Ozark and Ouachita highlands, including two of our specimens, to the race *V. v. regalis* on the basis of a critical study of the skull. He examined specimens from Tahlequah, Stillwater and Lake Holdenville.

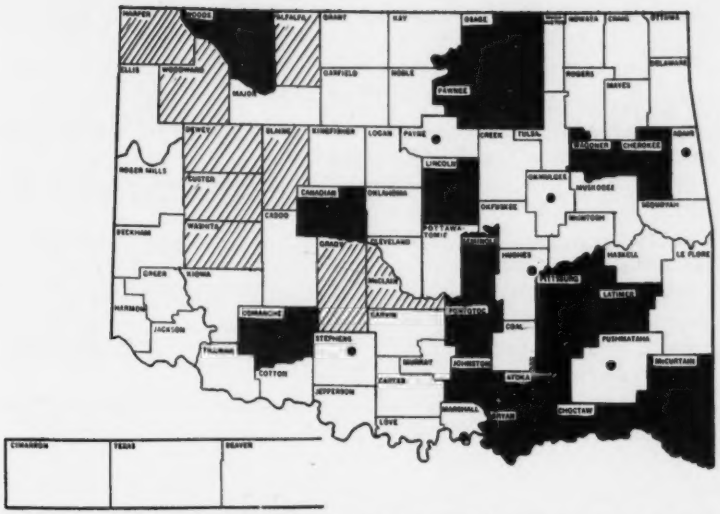

Figure 1. Map of Oklahoma, showing localities from which specimens of red foxes are known (black dots), counties from which trappers indicate red foxes have been taken (black areas), and counties from which trappers report no red foxes have been taken (shaded areas).

The only specimens from the state in which the adult pelage has been examined were the one from Stillwater, the one from Buzzard Creek, and the one from Bray. The latter was the typical red color of the eastern red fox, but the other two were the tawny-red typical of the subspecies *regalis*. A juvenile from Stillwater was a dark red color, but a subadult from Proctor, while darker than the ones from Stillwater or Buzzard Creek, was more tawny than either the Bray specimen or the Stillwater juvenile. Many of the federal hunters reporting in reply to the questionnaire indicated, without verification on our part, that there is at present considerable importation of red foxes into the state by foxhound fanciers. According to these reports this is done rather secretively, supposedly to provide more game for the hounds. The extent of this practice will probably never be known, nor the exact sources of the animals thus imported.

The above data indicate that the Mississippi Valley fox, *Vulpes vulpes regalis*, is the form found in the Ozark and Ouachita districts of Oklahoma, but that elsewhere in the State a red variety, probably *V. v. fulva* is native or has been introduced. The result of introductions of the latter into the hills of eastern Oklahoma, if measurable, probably will result in the degradation of the native race into a hybrid

population difficult to define and impossible to assign to any subspecies.

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RELICT SPECIES OF THE CHIHUAHUAN DESERT

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ABSTRACT. Aridity on the Chihuahuan Desert of the southwestern United States and northern Mexico was relieved at times during the Pleistocene by pluvial periods. These moist periods permitted invasion of the desert by more mesic species from the east, and 14 such species exist on the desert today as relicts. They show little divergence from their main populations to the east. Five areas on the Chihuahuan Desert appear to be particularly suited to the existence of relicts. All of the relicts are in constant danger of extinction by either drought or flash flood.

Those of us who have worked on the Chihuahuan Desert have had an opportunity to study some aspects of desert formation and adaptation not available to workers on other deserts. The opportunity has arisen through the existence of pluvial periods during or immediately following the Pleistocene which apparently caused a gradual withdrawal of the eastern border of the desert and permitted the invasion of more mesic-adapted species from the east. The return of arid conditions in the Recent Era and the eastward advancement of the desert during the recent drought have enabled us to see how mesic species are gradually crowded out by increasing aridity during desert formation, and how some mesic species adopt a precarious form of existence around oases. In recent years, there has been considerable discussion in the literature of relict species which evolved during isolation resulting from Pleistocene splits in the ranges of ancestral species. The "recent isolates" of the Chihuahuan Desert, however, which for the the most part show little morphological divergence from their main populations to the east, have been largely ignored.

THE CHIHUAHUAN DESERT

The Chihuahuan Desert (Fig. 1), or Chihuahuan Biotic Province (of Blair, 1940, 1950; Dice, 1943; Goldman and Moore, 1945; Milstead, In press), lies in the area bounded by the 99th and 108th meridians and the 21st and 33rd parallels. The topography of the desert is rugged with alternating highlands and basins. For practical purposes, it may be thought of as a plateau with elevations from 2000 to 5000 feet that is crossed by several mountain ranges which rise to elevations of from 6000 to over 9000 feet. The climate is arid and of the

type characteristic of subtropical deserts. The average annual rainfall varies from 10 to 18 inches west to east and the major portion of the rainfall occurs between april and October. Spring and fall rains are gentle and the most beneficial, but most of the rain comes in summer storms. The summer rains are usually of the violent cloudburst type which may yield up to an inch or more of rain in half an hour. Such storms coupled with parched land and scant vegetation cause rapid run-off of the water and frequently produce violent flash floods in the watercourses. Rainfall, whenever it occurs, is usually very local, so that some areas may have less than two inches per year and others may have more than 20. Hot summers and cool winters are characteristic of the Chihuahuan Desert. The mean July temperature ranges from 76° to 84° F. and the mean January temperature ranges from 44° to 50° F. The daily temperature range averages about 30° F. Grass and desert shrubs form the principal vegetation with some broadleaf deciduous trees and evergreens in the mountains and along streams.

Formation of the western deserts is presumed to have begun in Miocene times and continued through Pliocene and into early Pleistocene times. Although it was quite arid, at least in places (Zinn, 1953), by the late Tertiary, the Chihuahuan Desert possibly did not reach its present state of aridity until the early Pleistocene with the final uplift of the Cordilleran ranges and the formation of arid conditions on the Great Plains. The present conditions of aridity probably existed throughout most of the Pleistocene, but it is generally agreed (Zinn, 1953; Martin and Harrell, 1957; Blair, 1958; and others) that pluvial periods did exist at times. The extent to which these periods of increased humidity spread over the Chihuahuan Desert and adjacent Edwards Plateau and their effects on the fauna and flora have been the subject of considerable debate in recent years. Martin and Harrell (1957) and others have taken the view that the pluvial periods did not permit the formation of more than a cool savannah or open woodland through central and south Texas at any time during the Pleistocene. On the other hand, Blair (1958) and others have argued that the pluvial periods were extensive enough to have permitted the formation of a cool forest corridor throughout Texas at some time in the Pleistocene. The relicts of the Chihuahuan Desert present no evidence to support either side of the question. Several of the species are typically forest forms and could have reached the Chihuahuan through a forest corridor. The others could have reached the Chihuahuan during pluvial times at an earlier or later date. On the other hand, no forest corridor was necessary even for the forest forms. All of them range

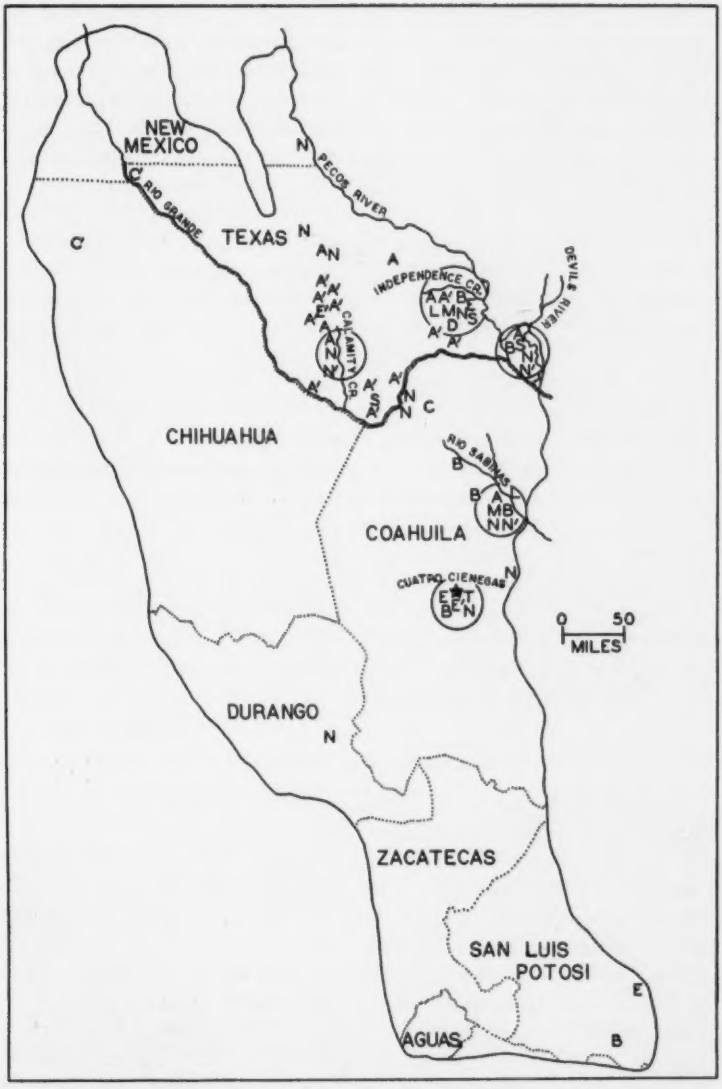

Figure 1. The Chihuahuan Desert and the approximate localities at which relict species have been recorded: A, *Acris crepitans*; A', *Ancistrodon contortrix*; B, *Bufo valliceps*; C, *Coluber constrictor*; C', *Chrysemys picta*; D, *Diadophis punctatus*; E, *Eleutherodactylus latrans*; E', *Eumeces tetragrammus*; L, *Lygosoma laterale*; M, *Micrurus fulvius*; N, *Natrix erythrogaster*; N', *Natrix taxispilota*; S, *Syrrhophus marnocki*; and T, *Terrapene coahuilae*. Circles indicate areas of relict species concentrations.

across the grassy Texan Biotic Province (of Blair, 1950) to reach or cross the Balcones escarpment (see Brown, 1950, for Texas locality records). All but two of the relicts (*Eleutherodactylus latrans* and *Syrrohophus marnocki*) range no farther west than the Balcones Escarpment or the eastern portion of the Edwards Plateau. Thus, some increase in humidity was necessary for their spread to the Chihuahuan Desert, but this could have been accomplished under only a slight increase (6 to 10 inches) in annual rainfall. Martin and Harrell (1957) have argued that other relicts in Texas and Mexico, notably the plethodontid salamanders, reached the areas in which they are now relictual by mid-Cenozoic times. The absence or small amount of morphological divergence exhibited by all but one (*Terrapene coahuilae*) of the Chihuahuan relicts, in comparison with other populations of their respective species, indicates that the invasion of the desert by most of the relicts took place a very short time ago; i.e., during or immediately following the Pleistocene.

In recent years (1949–1957), a severe drought caused a decrease of four to six inches in the annual rainfall of the eastern Chihuahuan Desert, where all but one (*Chrysemys picta*) of the relict species occur, and permitted the desert to extend eastward along the Rio Grande at least as far as the Devils River. It also caused a lowering of the water table in many areas and this contributed to the failure of numerous springs and seeps (notably Leon Spring at Fort Stockton) and reduced flow of all of the permanent streams. Extirpation of the relict species at many localities probably followed.

ACCOUNT OF SPECIES

Altogether 14 species are here recognized as relict species on the Chihuahuan Desert. These consist of four amphibians and ten reptiles. All of the amphibians are salientians. Only one salamander (*Ambystoma trigrinum*) is known from the Chihuahuan Desert and it is not here considered to be a relict species. The reptiles include two turtles, two lizards, and six snakes.

The fourteen species have a number of things in common: (1) all exist on the Chihuahuan Desert as apparently disjunct populations considerably removed from the main portion of the range of their species; (2) all or most of them represent the more mesic or hygric elements of their respective faunae within their normal range outside of desert areas; (3) their distribution on the Chihuahuan Desert is spotty rather than widespread and is typically restricted to the more mesic areas such as damp canyons, springs, or permanent streams; and

(4) away from these mesic areas the country is much more arid than any of that within the major portion of their range.

These are the criteria which have been used in deciding which species to include in the list of relicts. In time, as more becomes known about the distribution and habits of these species, some may be deleted from the list. Seven other species perhaps should be included: *Hyla arenicolor*, *Rana pipiens*, *Chelydra serpentina*, *Sceleporus olivaceus*, *Gerrhonotus liocephalus*, *Opheodrys aestivus*, and *Drymobius margaritiferus*. All seven answer the requirements of one or more of the criteria listed above, but they have not been included because their widespread distribution in North America or in areas contiguous with the Chihuahuan Desert leaves considerable doubt as to whether or not they should really be thought of as disjunct species.

All of the relict species have become adapted to life on the Chihuahuan Desert by restriction of habitat. For most, this has meant restriction to areas of permanent water, and, for some, restriction to other types of suitable habitats. Presumably, curtailment of habitat would also involve the necessity of adapting to a restricted diet and to other changes in habits. Adaptation to a desert climate would also necessitate modifications relative to temperature tolerance. Changes in habits to adapt to a restricted habitat in a desert climate have been more extensive in some relict species (e.g. *Terrapene coahuilae* or *Lygosoma laterale*) than in others (e.g., *Acris crepitans* or *Natrix erythrogaster*.)

The approximate localities at which the relict species have been recorded on the Chihuahuan Desert are shown in Fig. 1. An annotated list of the species follows below.

Eleutherodactylus latrans Cope. The Barking Frog has been recorded from two Chihuahuan Desert localities in Mexico: five miles south of Cuatro Cienegas, Coahuila (Schmidt and Owens, 1944), and ten miles west of Naranjos, San Luis Potosi (Smith and Taylor, 1948). On the basis of circumstantial evidence, Milstead *et al.* (1950) listed it as a probable on the Stockton Plateau of Trans-Pecos Texas.

Syrrhophus marnocki Cope. The Cliff Frog has been recorded from three areas on the Chihuahuan Desert, all in Texas: Big Bend National Park (Schmidt and Smith, 1944); the Devils River (Brown, 1950); and the Stockton Plateau (Milstead *et al.;* 1950). Collections in Big Bend National Park in 1957 and 1958 yielded several additional specimens and indicated that the population is still quite strong. It appers to have disappeared from the Stockton Plateau, however.

Bufo valliceps Wiegmann. Schmidt and Owens (1944) record the Gulf Coast Toad from four localities in Coahuila: La Babia, near Muzquiz,

Cuatro Cienegas, and La Mariposa. Taylor (1952) records it from Capulin, San Luis Potosi. In Texas, it has been recorded from the Devils River (Brown, 1950) and Independence Creek (Milstead *et al.*, 1950). Collections at both of the Texas localities in 1957 failed to yield any additional specimens. Taylor (1952) has reported that the Chihuahuan population in San Luis Potosi has developed certain morphological characteristics which distinguish it from other populations of the species.

Acris crepitans Baird. The Cricket Frog is one of the more widespread relicts of the Chihuahuan Desert, and has been recorded from a number of localities. Coahuila: Sabinas River near Musquiz (Schmidt and Owens, 1944) Texas: Calamity Creek and tanks on Blackburn's Ranch between Paisano Pass and Cathedral Mountain (Strecker, 1909); Leon Springs at Fort Stockton (Netting and Goin, 1946); Phantom Lake near Toyahvale and two to three miles west of Toyahvale (Wright and Wright, 1949); and Independence Creek (Milstead *et al*, 1950). Recent collections at all of the Texas localities except Blackburn's Ranch have failed to yield any specimens of this species. Cricket Frogs are usually abundant wherever they occur and failure to collect them suggests extirpation or reduced numbers as a result of drought or other factors.

Terrapene coahuilae Schmidt and Owens. This species is a Chihuahuan Desert endemic known only from the type locality, Cuatro Cienegas, Coahuila. It does, however, appear to be rather abundant at the type locality and may in time be found at other sites in the same general area. This is perhaps the most interesting species of the Chihuahuan Desert because, in its adaptation to desert life, it has changed from a terrestrial to an aquatic habitat. So far as known, this is the only aquatic member of the genus *Terrapene*. In adopting an aquatic existence, *T. coahuilae* has undergone a loss of pigmentation on both soft and hard parts, and has developed a more streamlined shell and more extensive webbing than other members of the genus. This species is included here as a relict species of the Chihuahuan Desert because I presume that it evolved from remnants of a population of *Terrapene carolina* which inhabited the area at an earlier time. At what time these remnants became isolated and what segment of the *T. carolina* complex they represented is subject to controversy. *Terrapene carolina* does not now occur in either the Balconian biotic province (of Blair, 1950) or the Tamaulipan biotic province (of Dice, 1943; Goldman and Moore, 1945; Blair, 1950) which lie immediately to the east of the Chihuahuan Desert. Representatives of this species did occur in both of these provinces at the close of the Pleistocene (Milstead, 1956;

see also Auffenberg, 1958) and perhaps earlier. Invasion from either of these provinces could have occurred during any of the pluvial periods, and the invasion probably extended across most of the Chihuahuan Desert. Evolution in the genus *Terrapene* has taken place at a very slow rate. This fact and the differences which exist between *coahuilae* and other members of the genus suggest that isolation of the *coahuilae* ancestors may have taken place in pre-Pleistocene times. On the other hand, the *coahuilae* differences are not vastly greater than those which exist between the extinct *T. putnami* and *T. c. triunguis* (See Auffenberg, 1958), and doubtlessly *coahuilae* and its ancestors have been subjected to more rigorous selective pressure than any other members of the genus. The portion of the *Terrapene carolina* complex from which *coahuilae* evolved is obscured by the fact that *coahuilae* exhibits both primitive and advanced characteristics. The postorbital bar is as strong in *coahuilae* as it is in *T.c. major* and other primitive forms, while the plastral ratios agree with those of *T.c. triunguis* which I consider to be the most advanced member of the genus.

Chrysemys picta belli Gray. The Western Painted Turtle has been recorded from only two localities on the Chihuahuan Desert: Rio Santa Maria near Progresso, Chihuahua (Smith and Taylor, 1950), and El Paso county, Texas (Brown, 1950). Brown reports that the El Paso specimens are no longer available.

Lygosoma laterale Say. The Ground Skink has been recorded from two localities in Coahuila by Schmidt and Owens (1944): Nogales and the Sabinas River near Musquiz. In Texas, it has been recorded from Independence Creek (Milstead *et al*, 1950). Collections at the Texas locality in 1957 yielded no additional specimens.

Eumeces tetragrammus Baird. There are only two records of the Four-lined skink on the Chihuahuan Desert. Strecker (1909) records "one example from among rocks, on the road from Paisano to Blackburn's." A second record was recently obtained three miles west of Cuatro Cienegas, Coahuila (Zweifel, 1958).

Natrix erythrogaster transversa Hallowell. The Blotched Water Snake is the most widely distributed relict on the Chihuahuan Desert. Coahuila: Schmidt and Owens (1944) report specimens from the Sabinas River near Musquiz, Hermanas, and Cuatro Cienegas. New Mexico: Pecos River at Carlsbad (Conant, 1955). Texas: Calamity Creek (Strecker, 1909); Rio Grande at Boquillas (Murray, 1939; Schmidt and Smith, 1944; Brown, 1950; Minton, 1958); near Toyahvale, Phantom Lake near Toyahvale, and 25 miles northwest of Toyahvale (Brown, 1950); Independence Creek (Milstead *et al.*, 1950); and Hot Springs, Big Bend National Park (Minton, 1958).

Collections at the Toyahvale locality in 1956, at Calamity Creek in 1956 and 1957, and at the Independence Creek locality in 1957 yielded no additional specimens. Specimens have been collected at Boquillas and Hot Springs in recent years.

This species has also shown a habitat change in adaptation to life on the Chihuahuan Desert, but it is not as major a change as that exhibited by *Terrapene coahuilae*, nor has it brought on morphological changes other than paler coloration. Over most of its geographic range, *Natrix erythrogaster* is predominantly a nocturnal species. At the Independence Creek locality, Milstead *et al.* (1950) recorded it as predominantly diurnal. The same habit is implied by Strecker's (1909) reference to these snakes as "frequently observed in Calamity Creek." The snakes have apparently retained nocturnal habits at Boquillas. The Stockton Plateau and upper Calamity Creek typically have much cooler nights than the Rio Grande Valley, however. Competition with *Ancistrodon contortrix* at Independence Creek may have influenced the adoption of diurnal habits by *Natrix erythrogaster*.

Natrix erythrogaster bogerti Conant. Known only from the type locality: Rio Nazas near La Goma, Durango. (Conant, 1953).

Natrix taxispilota rhombifera Hallowell. The Diamond-backed Water Snake has been recorded from Las Rusias, Coahuila (Schmidt and Owens, 1944); The Devils River (Brown, 1950); and Calamity Creek (Strecker, 1909). Collections at Calamity Creek in 1956 and 1957 and at the Devils River in 1957 yielded no additional specimens.

Diadophis punctatus arnyi Kennicott. The Prairie Ring-neck Snake has been recorded from only one locality on the Chihuahuan Desert: The Stockton Plateau in the Independence Creek area(Milstead *et al.*, 1950)

Coluber constrictor stejnegerianus Cope. Schmidt (1953) records the Rio Grande Racer as extending westward along the Rio Grande to Northern Coahuila. Apparently the only specific locality record is that given by Zweifel (1954); eight miles southwest of Piedra Blanca, Sierra del Carmen, Coahuila.

Micrurus fulvius tenere Baird and Girard. Only two records exist for the Texas Coral Snake on the Chihuahuan Desert. Schmidt and Owens (1944) recorded it from Las Rusias near Musquiz, Coahuila, and Milstead *et al.* (1950) recorded it from Independence Creek.

Ancistrodon contortrix pictigaster Gloyd and Conant. Although it does not have as widespread a distribution on the Chihuahuan Desert as some of the other relict species, there are more locality records and more specimens of the Trans-Pecos copperhead than any other relict. All of the records of this subspecies are in Texas: Paisano Pass

(Stecker, 1928); Mitre Peak and Musquiz Creek between Alpine and Fort Davis (Gloyd and Conant, 1943;) Big Bend National Park (Gloyd and Conant, 1943; Schmidt and Smith, 1944; Minton, 1958); Sanderson and Limpia Canyon near Fort Davis (Flury, 1949); Independence Creek (Milstead *et al.*, 1950); Rosillos Mountains (Minton, 1958); Black Gap Wildlife Management Area (Axtell, 1959); 10 miles east of Sanderson (Sul Ross State College specimen); and Stonehouse Canyon, 3 miles west-northwest of Lajitas (Texas Tech College specimens).

The Independence Creek population of copperheads was one of the greatest aggregations of poisonous snakes ever recorded outside of a den, but it was all but extirpated by a flood in 1954. Collections along Independence Creek in 1957 yielded only a very few specimens.

The copperhead population in Stonehouse Canyon is apparently the remnant of another aggregation. In the past, the canyon contained three springs: two in the upper canyon and one in the lower. Water flow from the upper canyon springs was of sufficient volume to warrant the building of a dam eight feet high to impound the waters. At present, however, all three springs have been reduced to seeps. Seepage from the two above the dam is not sufficient to cause even a puddle on the Canyon floor, but seepage from the lower canyon spring maintains a pool about 30 feet long by 10 feet wide by 3 feet deep. During two weeks in July, 1958, J. W. Gibbons and I collected 11 copperheads from this pool and, in August, Ernest Tanzer collected two additional specimens. Food available to the copperheads around the pool consists of insects, sunfish (*Lepomis sp.*), and frogs (*Rana pipiens*).

Altogether, thirteen specimens from Stonehouse Canyon are in the Texas Tech Zoology collections: ten of those originally collected there and three well-developed embryos from one of the females. When the coloration and subcaudal counts of these specimens are compared with other material, they tend to confirm the evidence that the specimens from Independence Creek are intermediate between *A. C. pictigaster* and *A.c. laticinctus*. The subcaudal counts are:

pictigaster

Stonehouse Canyon
Females: 54 — 56 : 54.5 (4 specimens)
Males: 55 — 60 : 58.0 (9 specimens)
Davis Mts. and Big Bend National Park (Gloyd and Conant, 1943)
Females: 52 — 56 : 54
Males: 57 — 59 : 58

pictigaster x *laticinctus* — Independence Creek (Milstead, et al., 1950)
Females: 43 — 60 : 51.5 (42 specimens)
Males: 50 — 59 : 54.5 (40 specimens)
laticinctus — Edwards Plateau, (Gloyd and Conant, 1943)
Females: 37 — 52 : 45
Males: 44 — 54 : 48

This does indicate, however, that the Independence Creek specimens are somewhat closer to *pictigaster* than to *laticinctus*. The Trans-Pecos Copperhead, *Bufo valliceps* in San Louis Potosi, and *Terrapene coahuilae* are the only relicts that have exhibited morphological divergence during their isolation of the Chihuahuan Desert.

LOCAL CONCENTRATIONS OF RELICTS

Some of the relict species of the Chihuahuan Desert have been recorded only once or a few times, others have been recorded several times and occasionally in aggregations, and others appear to be locally abundant wherever they have been recorded. Most of the relicts are restricted to the eastern portion of the desert, but there is no definite pattern to their distribution. Five localities, however, appear to be unusually suitable for mesic species in that several relict species have been recorded at each, and some of these species have been recorded in abundance. Two localities are in Coahuila: Cuatro Cienegas with five relict species and the Sabinas River in the Musquiz area with six species. The other three localities are in Texas: the Devils River with five species, Calamity Creek with three, and Independence Creek with nine. Twelve of the fourteen relict species are included in those represented at these localities. The species and the five localities are shown in Fig. 1.

Calamity Creek has the least number of relicts recorded at any of the five localities, and all of the records are those of Strecker (1909). The three species recorded by him (*Acris crepitans*, *Natrix erythrogaster*, and *Natrix taxispilota*) are well known in most parts of Texas and are sufficiently distinct to rule out any possibility of error in Strecker's identifications. Several trips in 1956 and 1957 to the same general area where Strecker collected failed to yield any further specimens. Calamity Creek has suffered greatly in the recent drought and the relict fauna may have been extirpated.

The Independence Creek area of the Stockton Plateau has the greatest number of recorded relicts of any area in the Chihuahuan Desert. This is due in part to the area's proximity to the eastern edge of the desert and in part to the mesic habitat provided by constantly flowing

springs and a dense live-oak motte. Seven of the nine relicts of the area are largely restricted to the motte and the creek. A savage flood through the area in 1954 either extirpated or seriously hurt the populations of these seven species. Collections made in the summer of 1957 yielded a few additional specimens of the copperhead, but none of the other relicts recorded by Milstead *et al.* (1950). During our stay in 1949, the forest floor was covered with rich humus and a six to eight inch leaf litter. In 1957, the forest floor was largely bare and drift wood and other flood litter was still lodged up to 20 feet above the ground in trees.

Thus, the relict species restricted to areas of permanent water are in constant danger of extinction from two sources; drought and flash flood. The same species might survive a flood in a more mesic area, but floods in those areas do not have the rapid rise and scouring effect of flash floods. The mesic species which are most likely to survive as relicts on a desert are those which are the most hygric and can adapt to survival around permanent water. It is ironic that they are in ever danger of extinction by too little water or too much.

TABLE 1

Relict species of the Chihuahuan Desert, the faunal elements they represent, and the biotic provinces from which they are presumed to have invaded the Chihuahuan Desert.

Species	Faunal Element	Origin of Desert Invasion	
		Balconian	Tamaulipan
Eleutherodactylus latrans	Balconian	x	..
Syrrhophus marnocki	Balconian	x	..
Bufo valliceps	Gulf Coast	x	x
Acris crepitans	Eastern U.S.	x	?
Terrapene coahuilae[1]	Chihuahuan	x	x
Chrysemys picta	Eastern U.S.	..	..
Lygosoma laterale	Eastern U.S.	x	?
Eumeces tetragrammus	Gulf Coast	..	x
Natrix erythrogaster	Eastern U.S.	x	x
Natrix taxispilota	Eastern U.S.	x	x
Diadophis punctatus	Eastern U.S.	x	..
Coluber constrictor	Eastern U.S.	..	x
Micrurus fulvius	Gulf Coast	x	x
Ancistrodon contortrix	Eastern U.S.	x	..

[1] Presumed to have evolved on the Chihuahuan Desert in Pleistocene or pre-Pleistocene times, but presumed to have evolved from *Terrapene carolina* which was in both the Balconian and Tamaulipan piotic provinces at least during the Pleistocene and possibly earlier.

BIOGEOGRAPHIC RELATIONSHIPS

The fourteen relict species of the Chihuahuan Desert are representative of four faunal elements. Two species are largely limited in distribution to the Balconian Biotic Province of central Texas, and one species is limited to the Chihuahuan Biotic Province. Three species are widely distributed on the Gulf Coastal Plain and eight are widely distributed in the eastern United States. All but one (*Chrysemys picta*) of the relicts are presumed to have invaded the Chihuahuan Desert during pluvial times from either the Balconian Biotic Province (of Blair, 1950), the Tamaulipan Biotic Province (of Dice, 1943; Goldman and Moore, 1945; Blair, 1950), or both. The Balconian province merges with the desert for a considerable distance along the Pecos and Devils rivers in Texas and the Sierra del Carmen of Coahuila. The Tamaulipan province of the Coastal Plain of south Texas and eastern Mexico grades into the Chihuahuan Desert in south central Texas near Del Rio, in eastern Coahuila, and eastern and southern San Luis Potosi. Absence of barriers between the desert and these two provinces has produced broad transition zones in which there is a very gradual shift from one environment to the other. Thus, only a slight increase in humidity would permit invasion of the desert by species from both the Balconian and Tamaulipan provinces. The relict species, the faunal elements they represent, and the biotic provinces from which they are presumed to have invaded the Chihuahuan Desert are listed in Table 1.

SUMMARY

Pluvial periods during or immediately following the Pleistocene apparently caused a gradual withdrawal of the eastern border of the Chihuahuan Desert, and this permitted the invasion of more mesic-adapted species from the east. Most of these invaders presumably died with the return of desert conditions, but some species remained as relicts which cling to a precarious existence around oases. Fourteen such species occur on the Chihuahuan Desert. All are isolated from the major portion of their species range to the east, but most have shown little morphological divergence. *Terrapene coahuilae* is the one exception. It is suggested that it evolved on the Chihuahuan Desert from *Terrapene carolina*. The invasion by *T. carolina* may have taken place in pre-Pleistocene times. *Ancistrodon contortrix* and *Bufo valliceps* have undergone some morphological divergence and *Natrix erythrogaster* appears to have changed its habits from nocturnal to diurnal. A recent collection of copperheads from Presidio county, Texas, is compared with specimens from central Texas and the Stock-

ton Plateau. It is concluded that the specimens from the Stockton Plateau are intermediate between *Ancistrodon contortrix laticinctus* and *Ancistrodon contortrix pictigaster*.

Five localities on the Chihuahuan Desert appear to be particularly suited for relict species in that 12 of the 14 relicts are represented in collections from those areas. Drought and flood in recent years appear to have annihilated or greatly reduced the numbers of relict populations in several areas.

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THREE NEW NORTH AMERICAN DROSOPHILIDAE

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ABSTRACT. Three new species of the dipterous family Drosophilidae are described: *Chymomyza olympia* from Washington, formerly reported as "?*distincta* Egger"; *Leucophenga neovaria* from Florida, Puerto Rico, Jamaica, El Salvador, Nicaragua, Colombia and Venezuela; and *Amiota huachucae* from Arizona, formerly reported as *albavictoria* Patterson and Mainland.

Two of the new species described here have been previously reported from the United States, but as tentative or erroneous identifications of named species. The Holotypes are in the *Drosophila* Type and Reference Collection of the University of Texas. Some paratypes of each species are being placed in the U.S. National Museum collection.

Chymomyza olympia, NEW SPECIES

This species was reported by Wheeler (1952) as "?*distincta* Egger"; Mr. E. B. Basden of Edinburgh has compared some specimens with the European species and found them to be distinct. *C. olympia* is readily separated from the other American species by the conspicuous black cloud near the wing tip.

Male. Mesonotum, scutellum, front, antennae and upper face all pale tan; lower face with a broad black transverse band. Cheeks, palpi and proboscis pale tan. Abdomen shining black except for the extreme base and the apical margin of the sixth tergite. All legs pale yellow; fore femora with the usual dense series of stout bristles along inner side. Costal cell blackened; a prominent black cloud in submarginal cell just below and beyond the apex of second vein; wing tip whitish.

Body length and wing length about 3 mm.

Known only from ten males collected in August, 1951, by the writer and William B. Heed from partially peeled fir logs and chips at the Dungeness Fork Forest Camp, Olympic National Forest, about ten miles south of Sequim, Washington. Holotype ♂ and seven paratypes from the above locality. The female is unknown.

Leucophenga neovaria, NEW SPECIES

This wide-ranging neotropical species has recently been found in Key West, Florida. Thorax, legs, halteres, front, face, antennae,

cheeks and palpi all pale yellowish tan. Female palpi of normal size and shape. Abdominal pattern as shown in the figure, very similar in the two sexes. Variation in abdominal pattern as follows: 2nd tergite often without the small dark areas; paramedian dark areas of tergites 4 and 5 variable in size, absent in the female from Florida; all dark areas tend to be larger in males. Genital arch and anal plates of male dark brown to black. On the average pinned specimen one can see three quadrate median black areas, three isolated paramedian spots, the first always largest, and two or three large black lateral areas (tergites 4–6).

Wings diffusely darkened over anterior half, progressively paler posteriorly; the darkening is more intense in two regions: over and below the first vein, and in the apical half of the marginal cell (reaching the apex of the 2nd vein), and continued across the 2nd vein into the submarginal cell. Neither crossvein is in an evident cloud although the area around the anterior crossvein is somewhat discolored.

Distribution: 4, Puerto Rico (Mayaguez; W. B. Heed; Coloso; L. F. Martorell, U.S.N.M. coll.), 2, Jamaica (Falmouth; M. Wasserman), 5, El Salvador (San Salvador, Santa Tecla, San Marcos Lempa; W. B. Heed), 2, Nicaragua (Managua; W. B. Heed), 1, Colombia (Santa Marta; W. B. Heed, M. Wasserman, H. Hoenigsberg), 1, Venezuela (Cumanacoa; M. Wasserman), 1, Florida (Key West, Oct. 28, 1959, "in fruit fly trap"; C. A. Bennett; in U.S.N.M. coll.).

Holotype from Mayaguez, Puerto Rico.

Amiota (Phortica) huachuae, NEW SPECIES

This species, from the Huachuca Mountains of Arizona, is very similar to *albavictoria* Patterson and Mainland (1944) and was reported under that name by Wheeler (1952). The two are most readily separated by the frontal coloration and the abdominal pattern. In *albavictoria* (see figure in Plate XI of Patterson and Mainland, 1944)

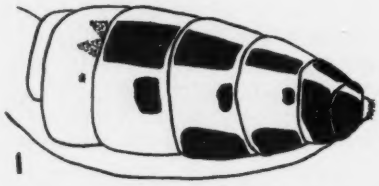

Fig. 1. *Leucophenga neovaria*, n. sp., abdominal pattern of female in dorso-lateral view.

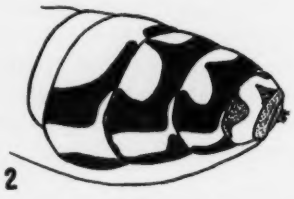

Fig. 2, *Amiota huachuae*, n. sp., abdominal pattern of female in dorso-lateral view.

the central portion of the front shows a large triangular brownish area reaching the lunule, strongly contrasting with the silvery white orbits and grayish white of the remainder of the front. The brown frontal triangle is sometimes uniformly dark, but in some specimens the darkness gradually diminishes laterally. In *huachucae* the front is almost wholly dull grayish white; the ocellar area is blackish brown as is a small area at each posterior corner, this area including the bases of the inner and outer verticals and the posterior reclinate orbital. The proclinate orbital stands on a small brownish spot. Some specimens also show a pair of diffuse, slightly elongate brownish streaks near the center of the front, one on each side of the midline. Other features of the head as in *albavictoria.*

Wings with both crossveins lightly clouded. Color pattern of legs as in *albavictoria;* male hind femur with an irregular row of stout bristles along inner side distally, only one or two such bristles in female. Abdominal pattern as shown in figure 2, similar to that of *albavictoria* but the fifth tergite with a weakly defined pattern rather than being all dark.

Body length up to 4 mm.

Holotype male and 7 paratypes from Ramsey Canyon, Huachuca Mountains, Arizona, collected June 1951 by W. B. Heed and the writer. This species, like others in the genus, has the annoying habit of flying around one's head, especially the eyes. The significance of this habit in *Amiota* is unknown.

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PATTERNS OF OVIPOSITION IN TWO SPECIES OF HYLID FROGS

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ABSTRACT. The patterns of oviposition of *Pseudacris streckeri* and *Hyla versicolor* are described. It is suggested that differences in ovipositional patterns of closely related species of anurans may act as ethological isolating mechanisms.

One of the most important mechanisms involved in maintaining species discreteness among anurans seems to be ethological isolation. The most outstanding of these ethological factors is the breeding call. The importance of the call has been firmly established by the experiments of Martof and Thompson (1958) and Littlejohn and Michaud (1959).

Fouquette (1959, p. 45) suggested that another possible ethological isolating mechanism lay in the difference in the ovipositional patterns of different species of frogs. During one of the call-discrimination experiments of Littlejohn and Michaud (unpublished laboratory notes) at the University of Texas laboratories, a male *Pseudacris triseriata* clasped a female *P. streckeri*. The female swam to the middle of the tank and began a typical oviposition pattern, whereupon the foreign male immediately released its hold. Thus the typical movements involved in oviposition for one species may act as a "release" mechanism (i.e., one causing the male to release his hold) in another species, hence an effective ethological isolating mechanism.

Oviposition pattern have been described for a number of species of anurans, and Gosner and Rossman (1959) have reviewed the literature rather well, hence only references of immediate significance will be repeated here.

We observed oviposition in *Pseudacris streckeri* and *Hyla versicolor* (the fast-trilled species of Johnson, 1959, and others). The observations were facilitated by use of the discrimination tank and associated equipment described by Littlejohn and Michaud (1959). At the end of a night's call-discrimination experiments, males were placed in the tank with one or more females that were responsive to the mating

calls. The males were induced to call by playing recorded calls of the species from a tape-recorder. The females responded to the male calls and amplexus occurred. Subsequent oviposition was observed for two pairs of *P. streckeri* and one of *H. versicolor*. In both cases oviposition began within five minutes after amplexus, but inasmuch as the females had been collected in amplexus some time earlier and had then been subjected to discrimination trials for two to four hours, it is probable that a much longer period of amplexus normally may precede oviposition.

OVIPOSITION PATTERN OF PSEUDACRIS STRECKERI

When amplexus occurred the female swam about until she contacted a suitable stem of grass just beneath the surface of the water. Free floating stems were rejected. The stem was grasped by her hands and her body was oriented so that the longitudinal axis paralleled the stem. She kicked about somewhat, seemingly testing to see if there were enough open water to accommodate her ovipositional movements. She then suddenly depressed her back strongly and rigidly, contracted her abdomen, and straightened her legs, maintaining this position for perhaps two or three seconds. As the female did this the male extended his legs downward, astraddle the female (sperm were probably released at this time). As the female relaxed her position, eggs appeared at the cloaca. She then pulled herself to the stem, bringing the eggs into contact with it, where they adhered in a small mass. Usually another batch of eggs was deposited in the same place in this manner and then the female swam about until contacting another suitable grass stem. The pattern was then repeated. The female of the first pair oviposited 72 times and a total of 376 eggs was deposited in masses containing from two to ten (mean 5.2). The female then repeated the pattern 12 additional times with no eggs produced. She then left the water and as she hopped across a clump of grass stems the male released or lost his hold. The entire period from amplexus to release lasted approximately one hour and 25 minutes.

The female of the second pair oviposited only 35 times. A total of 306 eggs was deposited in masses of from 2 to 14 (mean 8.7). The total time involved was about 50 minutes. At the completion of the last oviposition the female floated momentarily then kicked violently and the male released his hold.

Post-ovipositional behavior. Other males in the discrimination tank continued to call spasmodically, and when the male which had mated with the first female broke the amplexus he joined the chorus. The spent female responded immediately and approached the same calling

male which had fertilized her spawn. However, as he attempted amplexus, she jumped and swam away. As the male continued to call the female would re-orient and return to him, but each time he attempted amplexus she avoided him and fled. Both spent females approached and often made bodily contact with other calling males, but each time the male attempted amplexus the female successfully avoided him and moved rapidly away. It should also be noted that during oviposition the females exhibited no response to the calls of male frogs.

OVIPOSITION PATTERN OF HYLA VERSICOLOR (*"Fast-Triller"*)

Wright (1914) described oviposition in *Hyla versicolor* of New York, this presumably the slow-trilling species, but many details of the pattern were not included. Noble and Noble (1923) also mentioned some characteristics of the *versicolor* oviposition pattern. However, since all the aspects have not been adequately described, and since the pattern of egg deposition in the fast-trilling form observed here may differ in some manner from that in the slow-trilling form, we again report our observations in full.

Following amplexus the female swam and floated, apparently at random. Suddenly there was an abdominal contraction, followed immediately by the downward arching of her body so that her head was submerged and the cloaca was exposed above the surface of the water. As the female arched her body the male tightened his grip and slid forward so that his head was directly above that of the female, and he seemed to press his cloaca tightly against the spine of the female. Sperm were apparently released at this time, however, Wright (1914) claimed that fertilization occurred while the female was relaxed, between ovipositions. As the cloaca of the female was raised above the water a small egg-mass was expelled into the water. The female kicked as the eggs appeared and swam away from them. Most of the eggs floated, but many sank to the bottom. The female floated and swam about and then repeated the pattern. Altogether the female ovisposited 22 times. The number of eggs in each mass was not recorded, but it averaged considerably higher than in the *Pseudacris*. The time elapsed from amplexus to release was 26 minutes. After the last oviposition, the pattern was repeated five additional times with no eggs being released. The final arching of the body seemed much longer than the others and the male released his hold.

DISCUSSION

We have already indicated the only noticable difference in the oviposition pattern we observed for *H. versicolor* and that reported by Wright. We can compare the pattern we observed for *P. streckeri* with those for three other species of *Pseudacris* which have been described. Egg deposition in *P. triseriata* was detailed by Wright and Allen (1908) and by Livezey (1952). Oviposition in *P. t. feriarum* was described by Martof and Thompson (1958), and in *P. t. kalmi* by Gosner and Rossman (1959). Comparing the pattern for *streckeri* with these we find that it is quite similar. However, in the *streckeri* which we observed the female's legs are straightened stiffly at the time the body is arched, which does not appear to be true for the other three species. Another difference is that the legs of the male remain in a folded position on the back of the female during ejaculation in the other species, whereas in *streckeri* the legs are extended downward astraddle the female at this time. Other minor differences, such as in the method of attaching the eggs to the vegetation may be due to differences in technique of observation and interpretation. *P. t. feriarum* apparently deposits fewer egg masses composed of a generally greater number of eggs than *P. streckeri*, however, the time involved seems to be a little less in the latter species. *P. t. triseriata* apparently deposits more masses composed of about the same number of eggs, over a longer period of time than either of the others. But observations for all forms are based on such small samples that differences noted in all these numbers and times may not be meaningful.

The oviposition patterns for both call-types of the *H. versicolor* complex should be more carefully compared, since the two are undoubtedly different species (Johnson, 1959; Littlejohn, Fouquette, and Johnson, 1960).

In all hylids studied there is consistently a rigid downward arching of the body of the female just prior to the release of the gametes.

The mechanisms causing the male release following spawning are not clear. In the *Hyla* it appears to be a prolonged ovipositional arching by the female which causes the male to release. In the *Pseudacris* it may be the violent kicking, or moving from the water, or either, associated with the decrease in girth of the female.

Spent females react negatively to amplexus, and this is advantageous since it avoids waste of male's energies on a pairing which could not result in reproduction. The continued response to the male call on the part of a spent female is apparently a temporary residual response, since spent females brought in from the field have never

exhibited any response to male call in experiments at the University of Texas laboratories (Littlejohn, Fouquette, and Johnson, 1960).

ACKNOWLEDGMENTS

We gratefully acknowledge the assistance of George S. Drewry and Bobby J. Wilks in recording our observations. One of us (M.J.L.) wishes to acknowledge the receipt of a Hackett Studentship from the University of Western Australia, and a Fulbright Travel Grant during the time the investigations were carried out.

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NOTES

EUPHORBIA JEJUNA, NEW SPECIES FROM WESTERN TEXAS.— Because a larger paper by us on all the Euphorbieae of western Texas may not appear for months, we are describing a hitherto nameless species of *Euphorbia*. This species is undescribed apparently due to its strictly vernal flowering and restricted distribution in a botanically poorly known part of Texas. This species is a typical member of *Euphorbia* subgenus Chamaesyce Raf., and is related to varieties of *E. Fendleri* T. & G. and to *E. astyla* Englem. ex Boiss.

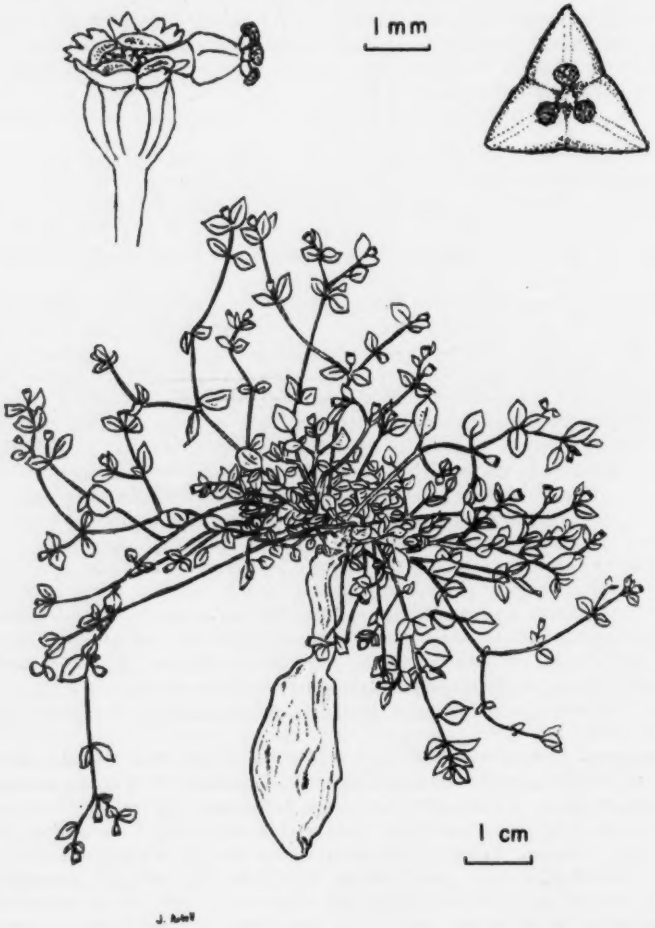
We are indebted to Dr. Hannah Croasdale for supplying the Latin diagnosis.

EUPHORBIA JEJUNA, ***new species.*** Plantae herbaceae perennes humilis, caules multi decumbentes aut ascendentes, breves, stipulis in squamam coalitis; glandes 4, poculiformes; appendiculae perspicuae, erectae aut patentes, plerumque in 4–6 segmentia acuta profunde dissectae aut usque ad basim in 4–6 lobos divisae; flores staminei ca. 12–25; styli 0.5 mm. long, integri, crasse rotundo-capitati; capsula 1.8–2.2 (–2.7) mm. long; semina 1.6–2.0 (–2.3) mm. long.

Glabrous low perennial herbs; taproot woody or somewhat fibrous and fleshy, either slenderly napiform and branched or tuberous, 3–14 mm. thick, dark-barked; stems 20–60, arising from a woody crown, annual, decumbent, 1–9 cm. long, 0.2–1.1 mm. thick, often flexuous, stramineous to brownish to reddish, much-branched, the branching often pseudodichotomous or even whorled with several leaves and branches emerging at a single node; internodes 0.5–2 cm. long. *LEAVES* opposite; blades rotundly obovate or ovate or nearly elliptical, 3–6 (–8) mm. long, 1.0–1.5 times longer than broad, apically rounded or angled (90–180°), basally shortly rounded or truncate and inequilateral, marginally entire, drying dull greenish or brownish, rarely glaucous, occasionally reticulate-veined, rather thin but with no tendency to roll on drying; petioles 0.7–1 mm. long; stipules on both sides of stem united into a very short scale which is lacerate, laciniate or rarely bifid, firm, reddish or purplish or white, lanceolate or muticous-deltoid, less than 1 mm. long, not conspicuous without a strong lens, or at floriferous nodes stipules rarely separate and each lanceolate on the upper side of the stem. *CYATHIA* solitary at the upper nodes in the forks; peduncles relatively long for this subgenus, 0.9–2 mm. long, erect, stramineous to reddish or purplish; involucres hemispheric or broadly campanulate, pubescent inside near the glands, 1.2–1.5 mm. long to the base of the glands, reddish or purplish or greenish with 5 paler or discolored stripes leading to the glands and sinus; glands 4, subequal, oblong, ca. 1.6 mm. long, cupped, yellowish green to olive green to reddish or purplish; appendages conspicuous, erect or spreading, white, ca. 0.6 mm. long, rarely entire or merely crenate, usually deeply dissected into 4–5 acute or acuminate lobes or even nearly parted to the base into 4–6 distinct segments, the form rather variable even on a single individual. *STAMINATE FLOWERS* 12–25 per cyathium. *PISTILLATE FLOWER*: gynophore exserted and reflexed and often bright red; ovary ovoid triangular, drying sordid olive green or brown; styles 3, ca. 0.5 mm. long, entire (not bifid), thickly round capitate, drying dark olive. *CAPSULE* ovoid, plumply triangular, olive-green, 1.8–2.2 (–2.7) mm. long; columella 1.7–2 (–2.3) mm. long, apically narrowed and acute, the facets with faint irregular transverse wrinkles or with up to 10 or 11

faint but definite low rounded transverse ridges, pale brownish or tawny-pink with a thick white coat; ecarunculate.

TYPE: Nolan County, Texas, a few miles west of Sweetwater between Interstate 20 (U.S. 80) and the city dump behind the Midway Motel, altitude 2250 feet, grama prairie on caliche uplands, with scattered *Dalea* shrubbery; growing with but quite distinct from *E. Fendleri* var. *Fendleri*, *M. C. Johnston 3967*, April 19, 1959 (Holotype SRSC; Isotypes SMU, Tex, etc.).



EUPHORBIA JEJUNA Warnock & Johnston sp. nov.

Other material seen: *Mitchell* County, N.W. quarter section 31, S. P. R. R. block 17, dry caliche slopes, prostrate, glaucous, *Richard W. Pohl 4819*, April 16, 1945 (SMU). *Terrell* County, limestone along highway 10 miles east of Dryden, alt. 2100 ft., *Warnock, Turner & Parks 54*, April 10, 1949 (SRSC, TEX); Limestone hills 20 miles west of Langtry, alt. 1880 feet, *Brown & Warnock 47324*, March 30, 1947 (SRSC). *Val Verde* County, limestone hills 10 miles west of Langtry, alt. 1860 ft. *Brown & Warnock 47311*, March 30, 1947 (SRSC); Limestone, 7 miles west of Langtry, alt. 1400 ft., *Warnock, Turner & Parks 188*, April 10, 1949 (SRSC).

The accompanying habit-sketch was supplied by Joan Axtell, mainly on the basis of *Warnock, Turner & Parks 54.—Marshall C. Johnston and Barton H. Warnock, Sul Ross State College, Alpine, Texas.*

BIRDS AND MAMMALS IN BARN OWL PELLETS FROM NEAR LAGUNA, CHIHUAHUA, MEXICO.—On July 9, 1959, the junior author collected nine intact owl pellets and four quarts of debris from weathered pellets in the hills northeast of the Laguna de Bustillos, Chihuahua, Mexico. Individual pellets could not be distinguished in the debris and many smaller elements had been washed into crevices and were not recovered, which accounts for the higher percentage of occurrence shown in Table 1 of animals of small size (for example *Perognathus*, *Peromyscus*, and *Mus*) in the intact pellets than in the debris. The material was found in clefts, scattered along approximately 100 yards of the base of a cliff that was 50 to 75 feet in height. While the material was being gathered, eight barn owls, *Tyto alba*, were observed. The cliff is situated along the top of a range of hills eight miles northeast of Laguna (a station on the railroad) at an altitude of approximately 7000 feet. The vegetation on the rocky slopes is primarily grassy. The lower, less rocky, slopes are cultivated and corn is the chief crop. Oak and juniper trees occur in the draws. The cliffs are approximately three miles from the Laguna de Bustillos. The area adjacent to the Laguna is mostly grazing land and is relatively barren. The soil of the lower slopes is mostly aeolian sand.

A field party from The University of Kansas Museum of Natural History camped in a sandy area about one mile from the shore of the Laguna from July 8 to 15, 1959, and collected vertebrates there and in the other habitats mentioned above between the Laguna de Bustillos and the place the owl pellets were obtained. Mammals were trapped, shot, purchased, and captured by hand.

Table 1 compares the number of each species (or genus) found in the owl pellets with the number taken by other methods. The numbers from pellets are the minimum numbers of each species (or genus) that could have contributed the elements observed. The nine complete pellets were analyzed individually and the numbers given are based on the assumption that parts of any one animal were recovered in only one pellet.

Pocket gophers *(Thomomys umbrinus)* occurred at all elevations from the shore of the Laguna to the cliffs, and were abundant in suitable soil. Twelve specimens were taken in gopher traps; more could have been obtained easily. The only species of *Perognathus* obtained was *Perognathus flavus*. Seven specimens were caught by hand, and one trapped. These little pocket mice also occurred at all elevations. Seven of the nine intact pellets contained *Perognathus flavus*. One pellet contained only one species of mammal, *Dipodomys ordii* (2 individuals); four pellets contained only two species of mammals; three pellets contained three species; and one pellet contained four species. The last-mentioned pellet contained 11 individuals of four genera. The pellet containing the largest number of individuals included parts of 12 *Perognathus flavus*, one *Dipodomys ordii*, and one *Onychomys torridus*. The only

species of *Dipodomys* obtained by trapping, and presumably the only species occurring in the area, was *Dipodomys ordii*. Kangaroo rats were abundant in the areas of sandy soils. Thirty specimens were preserved and others discarded. One individual of this typically nocturnal animal was seen in the afternoon running across the sand. Charles A. Long and the junior author observed a male and a female sparrow hawk, *Falso sparverius*, flying at about 10 a.m. on July 10; the male was shot, and was found to be carrying the posterior half of a kangaroo rat. Charles A. Long and William N. Berg observed a barn owl that captured a kangaroo rat on the third pounce, at about 10 p.m. on July 8.

The *Peromyscus* in the owl pellets belonged to at least two species. The five *Peromyscus* trapped included two *Peromyscus boylii* from eight miles northeast of Laguna, and three *Peromyscus maniculatus* from the northeast side of Laguna de Bustillos. The one *Neotoma* trapped was *Neotoma albigula;* the *Neotoma* in the owl pellet could not be identified to species.

Other kinds of small mammals obtained in the area but not recovered in pellets were *Myotis subulatus*, the small-footed myotis, one specimen; *Eutamias dorsalis*, the cliff chipmunk, four specimens; *Spermophilus spilosoma*, the spotted ground squirrel, five specimens; *Spermophilus variegatus*, the rock squirrel, seven specimens; and *Lepus californicus*, the black-tailed jackrabbit, two specimens. The single bat, *Myotis*, was shot; others were seen flying at dusk. The chipmunk, and the two squirrels are diurnal, which makes their capture by owls unlikely. The rock squirrel and the jackrabbit probably are too large for barn owls to capture.

No amphibians or reptiles were found in the pellets. Eight birds were found, including four brown-headed cowbirds *(Molothrus ater)*, three small fringillids, and one other small passerine. Two pellets contained remains of a cerambycid beetle, Genus *Prionus*, and the debris contained remnants of the same genus and of another unidentified beetle.

TABLE 1

Comparison of numbers of mammals recovered from owl pellets and collected by other means. Percentages are indicated in parentheses.

Species (or Genus)	Number in intact pellets	Number in debris from pellets	Number collected by other means
Thomomys umbrinus, southern pocket gopher	....	13 (10)	11 (18)
Perognathus flavus, silky pocket mouse	33 (58)	29 (23)	8 (13)
Dipodomys ordii, Ord kangaroo rat	7 (12)	48 (38)	30 (50)
Reithrodontomys megalotis, western harvest mouse	1 (2)	3 (2)	....
Peromyscus (species not determined)	8 (14)	11 (9)	5 (8)
Onychomys torridus, southern grasshopper mouse	3 (5)	4 (3)	1 (2)
Sigmodon minimus, least cotton rat	2 (4)	12 (10)	1 (2)
Sigmodon ochrognathus, yellow nosed cotton rat	....	1 (1)	3 (5)
Sigmodon (species not determined)	....	4 (3)	....
Neotoma (species not determined)	1 (2)	....	1 (2)
Mus musculus, house mouse	2 (4)	....	....
	57	125	60

The small size of the sample and the lack of knowledge of the percentage of time spent by owls in hunting in different areas preclude more precise interpretation of the data than the following: The relative numbers and kinds of small nocturnal mammals taken by barn owls agree with the numbers and kinds collected and observed in the area. For example, the most abundant two kinds are *Dipodomys ordii* and *Perognathus flavus;* the next most abundant two kinds are *Peromyscus* and *Thomomys umbrinus;* and other kinds are less abundant than any of the above four categories. The numbers of *Perognathus* and *Thomomys* in column three reflect intensity of collecting, for each was taken by a special method as noted above. The owls ate the same kinds that were collected, with only one exception; no *Reithrodontomys* was trapped. *Mus musculus* was obtained but none was preserved as a specimen.

Participation of the junior author in the field work and subsequent studies reported here was supported by a grant from the Kansas Heart Association administered through the University of Kansas program for undergraduate research participation.—*Sydney Anderson and Craig E. Nelson, University of Kansas Museum of Natural History, Lawrence.*

CIRSIUM TURNERI (COMPOSITAE), NEW SPECIES FROM TRANS-PECOS TEXAS.—Plantae herbaceae perennes; caules anni, herbacei, 5–30 ex unaquaque corona orientes, 15–45 cm. long., nisi admodum infra capitula, simplices, 3 mm. crass., tenuiter arachnosi; internodi multo breviores quam folia; folia oblanceolata, pinnatim lobata; in caule media 10–15 cm. long., glabra, secundum costas, autem, tenuiter arachnosa, anguste amplexicaulia, in apice marginibusque spinosa; capitula sessilia, 60–80 flores habentia, campanulata, 3–4 cm. lat., 3.5–4 cm. long, anthera, in unoquoque caule (1–)3–5 terminaliter subcorymbose aggregata; phyllaria valde graduata, in 3–4 seriebus, lineari-lanceolata, purpurea, in margine tenuiter arachnosa; extima brevia spinis praedita, intima longe acuminata, carina rotunda atque cacuminibus stramineis applanatis praedita; receptaculum planum, alveolatum; corolla purpurea, tenuis; achaenia lineari-oblonga, ca. 5 mm. long., transverse tetragonalia, 4-costata, paululum lateraliter compressa, interdum falcata, glabra, staminae, nitida, ad basim angustata, per collare cartilagineum marginale, ad centrum per stylopodium persistans angustum columnare vel fungoideum superata; pappus ca. 2.5 cm. long., e serie duplici setarum tenuium rectarum subaequalium argentearum constans; setae ad basim paululum dorsiventraliter compressae, supra capillares teretesque, aliquantam plumositatem mollem praebentes, ad basim cohaerentes, ut monas decidentes.

Roots perennial, rupicolous, not dislodged from their crevices; crowns fibrous, woody, 8–30 mm. thick; stems annual, herbaceous, 5–30 from each crown, 15–45 cm. long, simple except just beneath the head-clusters, usually horizontal or drooping from cliff overhangs, 3 mm. thick, greenish brown with paler striae (excurrent midveins of leaves), thinly arachnose with flat jointed translucent hairs; internodes much shorter than the leaves. Leaves pale green, crowded, oblanceolate, pinnately lobed, 10–15 cm. long at midstem or much longer at base of stem and reduced beneath the heads, glabrous except thinly arachnose along the midveins, superficially microscopically pustular, basally narrowly clasping, apically and marginally spinose with principal spines slender, stramineous, 4–7 mm. long. Heads essentially sessile, not calyculately bracteate, 60–80-flowered, disposed in subcorymbose terminal clusters of (1–)3–5 per stem. Involucres campanulate, 2–3 cm. broad. Phyllaries strongly

graduated in 3–4 series, linear-lanceolate, rose-purple to Royal purple or magenta, the outermost only a fourth as long as the innermost, marginally thinly arachnose, spine-tipped and with distinct midribs, the innermost round-keeled, long-acuminate into flattened stramineous tips. Receptacles flat, 5–7 mm. wide, alveolate, thickly beset around the alveolae with white hairs ca. 10 mm. long. Corollas slightly exceeding pappus, rose-purple to magenta, very slender, divided more than half way into 5 very narrow lobes. Androecia surpassing corollas, slender, stramineous. Styles slender, rose-purple, slightly exceeding androecia. Achenes linear-oblong, ca. 5 mm. long, transversely tetragonal and four-ribbed, slightly laterally compressed, sometimes falcate, glabrous, stramineous, shining, narrowed basally, surmounted by a marginal cartilaginous flange and centrally by a narrow columnar or fungoidal persistent stylopodium. Pappus ca. 2.5 cm. long, of a double series of slender, straight subequal, silken-white bristles which are slightly dorsiventrally compressed basally, capillary and terete above, with some soft pulmosity, coherent basally, deciduous as a unit. TYPE. Brewster County, Texas, rare in limestone crevices, Doubtful Canyon, Gage Estate, Del Norte Mountains, alt. 4500 ft., *B. H. Warnock 7974*, July 11, 1948 (holotype, SRSC; isotypes, MIN, SMU, TEX, and others to be distributed).

The description applies to the type series and to the following collection from the same locality: *Warnock & Hinckley 7539*, Sept. 18, 1947 (SRSC). The following collections differ in that the leaves, particularly the lower surfaces, are arachnose: Brewster County, Chisos Mountains, crevices in high rocks, *M. S. Young s.n.* Aug. 11, 1915 (TEX, MO); Brewster County, rare on barren igneous bluffs in upper Pine Canyon, Chisos Mountains, alt. 5200 ft., *B. H. Warnock 9175*, Aug. 1, 1950 (SRSC); rare perennial in cave on limestone bluffs of Maravillas Creek canyon, Black Gap Refuge, alt. 3100 ft., *B. H. Warnock 12340*, May 28, 1955 (SRSC). The following sterile collection appears to extend the range farther east: Terrell or Brewster County, rare on limestone bluff overhangs along Rio Grande between Reagan Canyon and Sanderson Canyon, alt. 2000 ft., *B. H. Warnock 15870*, Dec. 28, 1957 (SRSC).

This species is closely related to *Cirsium Rothrockii* (A. Gray) Petrak and to other species of the same alliance, all of which occupy similar habitats in the southwestern United States.

Professor Gerald B. Ownbey of the University of Minnesota, long-time student of the genus, examined material of the type series, and said (personal communication) that it might belong to an undescribed species.

I am naming this new thistle for Dr. B. L. Turner of The University of Texas.

Hannah Croasdale of Dartmouth College, Hanover, New Hampshire, kindly supplied the Latin diagnosis. Dr. Ownbey read over the manuscript and kindly made valuable suggestions for its improvement.—*Barton H. Warnock, Sul Ross State College, Alpine, Texas.*

OBSERVATIONS ON OKLAHOMA TOADS.—(Mr. Otis M. King, Southwestern State College, Weatherford, Oklahoma, died on July 31, 1959. Since he was working for his doctorate under my direction, I have, with Mrs. King's approval, examined his notebooks. These contain the following notes which seem worthy of publication. Calculations were made by me from data recorded in the notebooks. Interpretations are avoided, since I write in Mr. King's name. A. N. Bragg, Univ. Okla.)

1. *Movements of Toads (Bufo).* Toads were collected, near Weatherford, Oklahome, marked by tattooing on the venter and/or toe clipping and released locally from May, 1958 to July, 1959. The tattooing was discontinued early in 1959 when it was found to fade badly over-winter.

Fourteen adult *Bufo woodhousei woodhousei* Girard, 2 of them males, were recovered from the many released. The shortest straight line distance between point of release and recapture was 0.08 mile. The longest was 1.16 mile. One female released on May 17, 1959, was repeatedly recovered throughout June a maximum of 0.16 mile away. Only 5 toads were recovered a minimum of 0.5 mile from the point of release. One was recovered 0.08 mile away in three weeks. Direction of movement was haphazard, about equally in all directions as based on straight line distance.

A single adult male of *Bufo cognatus* Say, released on August 23, 1958, was recovered 0.12 mile from point of release on May 29, 1959.

2. *Size range of adult Scaphiopus bombifrons Cope.* Seventy-two adult males (52 calling when collected) and 51 females were measured in mm. in snout-vent length (SV) and head width at angle of the jaws (HW). Mean values found were as follows:

Calling males (N=52): SV=55.06 (R=47–55); HW=20.83 (R=18.3–22.3).
Non-calling males (N=20): SV=56.75 (R=50–63); HW=20.55 (R=19–23).
Total Males (N=72): SV=56.31 (R—47–63); HW=20.75 (R=19–23.0).
Females (N=51): SV=49.55 (R=36–62); HW=18.62 + (R=14.0–22.0).

3. *Fast Development of Scaphiopus bombifrons.* Plains Spadefoot embryos have a very fast rate of development (Trowbridge and Trowbridge, 1937, Amer. Nat. 71:460). In one pool near Weatherford, tadpoles emerged in metamorphosis in 13–14 days from eggs. This is the shortest time reported for this species and compares favorably with the shortest known for *S. holbrooki hurteri*, 12–13 days (Bragg, 1948, Wasmann Collector 7:66).

4. *Differential Abundance of Two Spadefoots in Regions of Western Oklahoma.* On a night when both species were calling abundantly, *Scaphiopus couchi* Baird seemed much more abundant about Godebo, Kiowa County, than about Weatherford, Custer County, Oklahoma. Furthermore, this species became abruptly less abundant and *S. bombifrons* more so at or near the Washita River. It is still uncertain what factors are involved.

5. *A large adult female of Bufo woodhousei woodhousei* ate a turtle (between the size of a quarter and fifty-cent piece) placed with it. This is only the second time a toad of this subspecies has been known to eat a vertebrate, both times in captivity.

6. *A male Bufo w. woodhousei* was found near Weatherford, Oklahoma, with an extra right front leg. (*Note*: The specimen was not found in Mr. King's collection of specimens, but he told me of it and I have a Kodachrome slide taken by King which clearly shows the condition.—*Otis M. King, Weatherford, Okla.*

OCCURRENCE OF PULEX SIMULANS BAKER IN LOUISIANA.—Baker (Canad. Entom. 27:65, 1895) described *Pulex simulans* on the basis of specimens from Texas, noting that the species was close to *P. irritans* and might be easily confused with that species. Later, he apparently concluded that the differences which he had observed were of little importance, and he reduced *P. simulans* to the status of a variety of *P. irritans* (Proc. U.S. Nat. Mus. 27:379, 1904). Jordan and Rothschild (Parasitology 1(1):7–12, 1908) reviewed the genus *Pulex* and synonymized *P. simulans* with *P. irritans*. This situation was generally accepted by taxonomists for fifty years.

Recent detailed studies of aedeagal structures of fleas have permitted a more accurate evaluation of many taxonomic problems. Smit (Journ. of Parasit. 44:523–526) reviewed the material of the genus *Pulex* in the Rothschild Collection and con-

cluded that the two species were distinct. Separation is based primarily on several distinctive characteristics of the male genitalia, and females are not always separable. Smit recorded specimens of *P. simulans* from Montana, Arizona, New Mexico, Texas, Oregon, Mexico, British Honduras, Costa Rica and Cuba, in the Rothschild Collection, and from Texas, Kansas and Mexico in the U.S. National Museum Collection.

The importance of *Pulex irritans* as a parasite of humans, and the potential importance of both species as carriers of disease, make it desirable to ascertain the distribution of *Pulex simulans*, and to correct previous reports which were made before the two species were separated.

In a collection of fleas from northern Louisiana, we have discovered a series of specimens which are referable to *Pulex simulans*. Since these are in the nature of locality records, only the males are listed, although numerous females which probably represent the same species have also been taken. Collection data on these specimens are as follows: April 10, 1958, Ruston, Lincoln Parish, La., 1 male, host unknown; June 30, 1959, Downsville, Union Parish, La., 1 male, host unknown; July 8, 1959, Ruston, Lincoln Parish, La., 1 male, host unknown; July 11, 1959, Forest, West Carroll Parish, La., 3 males, from dog.

These collections are some 650 miles to the east of Devil's River, Texas, the type locality, and some 350 miles to the southeast of the nearest corner of Kansas. It is probable that further study will show *Pulex simulans* to be of wide occurrence over the intervening area, and in other southern states.—*Allen H. Benton, State University of New York College of Education, Albany, N.Y. and Herbert E. Shadowen, Louisiana Polytechnic Institute, Ruston, Louisiana.*

A MASS DIE-OFF OF THE MEXICAN BROWN BAT, *MYOTIS VELIFER*, IN TEXAS.—One of the most abundant of Texas bats is the Mexican brown bat, *Myotis velifer*. Large colonies are found in the many sinkholes and solution caverns of the Edwards Plateau in central Texas. This bat is not uncommonly found associated with human habitation. Burns, *et al.* (Amer. Journ. Publ. Health, 46, 9:1089–1097, 1956), report one instance of rabies in this species.

On January 31, 1959, the author, accompanied by Mr. Floyd E. Potter, Jr., made a descent into the Valdina Farms Sinkhole in northwestern Medina County, Texas. Mr. Potter had been in the cave some three weeks before and had noticed the presence of large numbers of dead bats. Previous trips had been made to this cave in January and February of 1957 at which time there were large colonies of *Myotis velifer*, *Tadarida brasiliensis* and *Mormoops megalophylla* present (Raun and Baker, Southwestern Nat., 3, 1–4: 102–106, 1959).

There were no live bats present on this occasion. In an inner chamber of the cave, where there had been an active nursery colony of *Myotis* in 1957, we found a large number of mummified remains hanging on the walls in the natural position of roosting bats. The remains were recognizable as *Myotis velifer* but were not in condition for laboratory analysis.

A count of the number of remains found hanging on 25 square feet of the wall and a rough extrapolation of the area where remains were visible indicated the presence of more than 500 dead bats. Additional remains, mostly skeletal fragments, were found in profusion on the floor and piled in crevices. Water flows through the cave on occasion, and in each place where there would be an eddy, there were piles of bones. The number of dead bats must have been several times the above estimate, perhaps reaching several thousand.

There is no way of knowing what caused the mass die-off. The remains probably had been in the cave since the preceding summer. Disease seems to be the most

reasonable answer. Eads, *et al.* (*Publ.* Health Repts., 70, 10: 995–1000, 1955) mention extremely high mortality in a colony of *Tadarida* as evidence of a possible high level of rabies infection during 1954–55.

This is, as far as I have been able to ascertain, the first record of mass die-off of *Myotis velifer*, and suggests that this species should be investigated more intensively with regard to its possible role in rabies transmission.

I should like to thank Dr. Richard B. Eads of the Texas Department of Health for critically reading this manuscript.—*Gerald G. Raun, Department of Zoology, University of Texas, Austin and The Welder Wildlife Foundation, Sinton. Contribution #44, Welder Wildlife Foundation.*

NOTES ON THE PARASITIC MITES OF SOME WEST TEXAS REPTILES.—In the course of a six and one-half month period three hundred and twenty-eight lizards representing eight different species were examined in a search for ectoparasitic mites. The samples of lizards were taken principally from Randall and Armstrong counties in the panhandle of Texas and Ward and Winkler counties in West Texas. Samples taken from four other Texas counties represent only a small percent of the total number of lizards collected. One (thirteen lizards) was made in Crosby and Lubbock counties located in the south plains and Edwards and Gillespie counties located in the south-central part of the state.

The first collection of lizards was made on the thirteenth of February and during a period which extended to the twenty-eighth of May the examination of one hundred and nine lizards produced negative results. The lungs of 60 (30 *Uta stansburiana* and 30 *Cnemidophorus tigris*) of the first lizards collected were removed and opened in a futile search for lung mites. The first infestation of mites was observed on lizards collected the twenty-eighth of May and from this date until the last collection on the seventh of August 11 per cent of th lizards examined had an infestation of mites (Table 1). These mites were, with the exception of those found on two lizards collected in Gillespie County, chiggers *(Trombicula (Eutrombicula) alfreddugesi)*. The two lizards *(Crotaphytus collaris)* from Gillespie County had a number of tick larvae *(Argasidae)* attached to their bodies.

TABLE 1

Results of a survey of eight species of west Texas lizards for mite and chigger parasitosis. Most specimens are from Armstrong, Randall, Ward and Winkler counties in western Texas.

Host species	Total No.of Lizards	No. lizards before May 28	No. lizards after May 28	No. parasitized
Uta stansburiana	222	55	167	4
Sceloporus undulatus	23	9	14	3
Sceloporus olivaceus	1	0	1	1
Cnemidophorus tigris	51	30	21	7
Cnemidophorus sexlineatus	17	0	17	0
Cnemidophorus tessellatus	4	4	0	0
Crotaphytus wislizeni	1	0	1	0
Crotaphytus collaris	9	1	8	3
Total	328	99	229	18

The number of chiggers found on a lizard varied from one to one hundred or more, but most of the infestations involved only four or five mites. There were nine instances when more than thirty chiggers were found attached to various parts of their host's body. When the infestation was light the mites were found most commonly under folds of skin on the lateral area of the lizard's neck. Lizards infested with a medium to heavy number of chiggers had mites attached in the postfemoral pocket of both the fore and hindlegs, under the ventral scales; on one lizard a chigger was found attached in a shallow fold posterior to the anus.

Three of the lizard species, *Cnemidophorus tigris*, *Cnemidophorus tesselatus Uta stansburiana*, have never been reported as hosts of *Trombicula (Eutrombicula) alfreddugesi* Berlese. The other five species which were involved in the study were *Sceloporus undulatus*, *Sceloporus olivaceous*, *Cnemidophorus sexlineatus*, *Crotaphytus collaris*, and *Crotaphytus wislizeni*. There were no mites present on the only specimen of *Crotaphytus wislizeni* examined.

In addition to the lizards examined, three snake species were also checked for the presence of parasitic mites. Specimens of the species, *Heterodon nasicus* and *Thamnophis marcianus*, were collected, in Crosby County in June and were found to be heavily parasitized with *Trombicula (Eutrombicula) alfreddugesi*. I was unable to find any previous record of the parasitosis of *Heterodon nascius* with this chigger. Two mites which were identified as members of the genus *Entonyssus* (Parasitoidea: Entonyssidae) were taken from the lungs of one of five specimens of *Crotalus atrox* collected in Scurry County, Texas, in March of 1959.—*John E. George, Department of Biology, Texas Technological College, Lubbock.*

FEEDING IN THE HOUSTON TOAD.—In the spring of 1959, Mr. John Wottring, of Houston, Texas, sent me eight adult males of *Bufo houstonensis* Sanders which I watched throughout the summer for feeding reactions. As expected, they fed upon various insects in typical toad manner; but they differed slightly from some other species of *Bufo* earlier studied (Bragg, Herpetologica 13: 189, 1957), because they seemed more selective: (1) Specimens of two species of scarabs were not eaten, although abundantly present. One of these was, perhaps, too large, although juveniles of *Bufo cognatus* and of *B. woodhousei woodhousei* of about the same size as the Houston toads often eat them. The other beetle was no larger than carabids eaten readily by the Houston Toads. One toad attacked one of the smaller species of June beetles, swallowed it easily, but soon disgorged it. Evidently, negative selection here is due to some factor other than mere size. (2) A recently metamorphosed spadefoot (*Scaphiopus bombifrons* Cope) about 12 mm. in length was eaten almost immediately when placed with these toads. Five small juveniles of *Bufo cognatus* were then offered. After a week, the smallest of these had disappeared, and presumably was eaten. The others were not attacked. This may have been a size relationship, since these bufos were fully as large as some beetles rejected.

The insects eaten by the toads included many small to medium sized carabids, several small beetles of unknown families, several Diptera, green lacewings, and many types of small moths. The last seemed "preferred" to beetles of approximately the same size and abundance.

In other habits, these toads were weak burrowers, having difficulty with hard packed soil into which juveniles of *B. cognatus* easily burrowed. They were more vocal than most toads also; one, for example, when startled, jumped with a loud squawk, although not touched. Specimens of the local Oklahoma species have never been known to do this.—*Arthur N. Bragg, University of Oklahoma Biological Survey, Norman.*

NEW HOST RECORDS FOR THE MESOSTIGMATID NASAL MITE RHINONYSSUS RHINOLETHRUM (ACARINA: RHINONYSSIDAE).—The mesostigmatid nasal mite *Rhinonyssus rhinolethrum* (Trouessart) is known to parasitize several species of anseriform birds. Strandtmann and Wharton (1958), *Manual of Mesostigmatid Mites*. Inst. Acarol. Contrib. No. 4, 399 pp.) list four species of geese (one listed only as "domestic goose"), ten species of ducks, and one species of merganser as hosts. As hosts may now be added the geese *Chen hyperborea*, Snow Goose; *Chen caerulescens*, Blue Goose; *Chen rossi*, Ross Goose; the ducks *Aythya valisineria*, Canvasback; *Anas discors*, Blue-winged Teal; and the merganser, *Mergus serrator*, Red-breasted Merganser.

Unless otherwise indicated the birds heads examined were obtained through the courtesy of Mr. Ben Moore, owner of the Public Poultry House, Beaumont, Texas, which cleans waterfowl shot by local hunters. Because of the manner in which the birds heads were obtained the place and date of collection cannot be pin-pointed. However, the general area from which the birds were taken is extreme southeastern Texas and extreme southwestern Louisiana, and the period of examination was December, 1959, and early January, 1960. The birds were identified before the heads were severed; or, in those instances when only heads were obtained, only those heads for which positive identification could be established were examined.

All mites were removed from the nasal chambers, cleared in Nesbitt's clearing fluid for approximately 24 hours at 55 degrees C., and mounted in Hoyer's modification of Berlese's mounting medium.

Twenty-four Snow Geese were examined, and 11 were parasitized by *R. rhinolethrum*. Total numbers of mites per bird, sex, and immature stages are as follows: 1 mite, a female; 1 mite, a female; 1 mite, a female; 2 mites, both nymphs; 2 mites, both females; 2 mites, both nymphs; 3 mites, 2 females, 1 male; 3 mites, 1 female, 2 nymphs; 4 mites, 3 females, 1 nymph; 11 mites, 8 females, 1 male, 2 nymphs; 29 mites, 14 females, 5 males, 9 nymphs, 1 larva.

Fifteen Blue Geese were examined, and six were parasitized as follows: 1 mite, a female; 1 mite, a female; 1 mite, unknown, mite list; 4 mites, 1 female, 2 males, 1 nymph; 12 mites, 10 females, 1 nymph, 1 larva; 18 mites, 6 females, 3 males, 9 nymphs.

Specimens of *R. rhinolethrum* from a Ross Goose were loaned for study by Dr. R. W. Strandtmann, Department of Biology, Texas Technological College, Lubbock, Texas. Through his courtesy we list this goose as a new host. One bird yielded three mites, all females. No collection data are available for this bird.

A single Canvasback duck examined had five mites, four females and one larva.

Twenty-two Blue-winged Teal ducks were examined, and seven were parasitized as follows: 2 mites, both females; 2 mites, 1 female, 1 nymph; 4 mites, 3 females, 1 male; 6 mites, 2 females, 4 nymphs; 8 mites, 4 females, 4 nymphs; 10 mites, all females; 58 mites, 38 females, 4 males, 16 nymphs.

One Red-breasted Merganser yielded two male mites. Strandtmann (1956, Proc. Entom. Soc. Wash. 58: 129–142) listed four mites from a species of *Mergus* and gave the probable species of the bird as *serrator*.

During this study *R. rhinolethrum* was also found in the following previously known host birds: *Anas acuta*, Pintail; *Anas carolinensis*, Green-winged Teal; *Anas platyrhynchos*, Mallard; *Aythya affinis*, Lesser Scaup; *Branta canadensis*, Canada Goose (a small race, probably Hutchin's Goose); *Mareca americana*, Baldpate; *Spatula clypeata*, Shoveller.

Several other anseriform birds not known as hosts were examined, but they yielded no mites. These birds are as follows: *Anas cyanoptera*, Cinnamon Teal; *Anas rubripes*, Black Duck; *Anser albifrons*, White-fronted Goose; *Aythya americana*, Red-head duck; *Aythya collaris*, Ringnecked Duck; *Dendrocygna autumnalis*, Black-bellied Tree-duck.

On the basis of ten host records Strandtmann (1958, J. of Parasitol. 37: 129–140) stated that apparently this mite is indigenous to birds of the family Anatidae, and he predicted that it would evenutally be found in other species of Anatidae. Subsequent investigations have added 13 more host birds in the Anatidae. Van Tyne and Berger (1959, *Fundamentals or Ornithology*. New York. 624 pp.) list 145 species of the family Anatidae. Although only 23 of these 145 species are known to be parasitized by *R. rhinolethrum*, such a variety of species is included in the host list that it is probable that most species of Anatidae harbor the mite.

The only non-anseriform species in which this mite has been found was a coot, *Fulica* sp., order Gruiformes, collected in Thailand. Strandtmann (1956, op. cit.) reported this record and stated that it was probably an accidental infestation. It seems safe to assume that this is true because the nasal mite typical of the coot and probably also of the family Rallidae is *Rallinyssus caudistigmus* Strandtmann. Since coots and ducks often associate, the possibility of interchange of their nasal mites certainly exists. Ducks and coots are not closely related, so there is undoubtedly a physiological barrier to the permanent establishment of the duck mite in the coot and vice-versa. Also significant is the fact that only one specimen of *R. rhinolethrum* was found in the coot examined by Strandtmann. Even more surprising than this one accidental record is that more such accidental records have not been reported.

The reference to *R. rhinolethrum* as the nasal mite of anseriform birds should not imply that it is an order specific parasite although most anseriform birds are in the Anatidae. Nasal mites are not known from the non-anatid anseriforms, and until these birds are studied it seems advisable to regard *R. rhinolethrum* as a family specific parasite.—*Robert W. Mitchell and William L. Rhodes, Lamar State College of Technology, Beaumont, Texas.*

THE DESERT SHREW, NOTIOSOREX, IN SAN MIGUEL COUNTY, NEW MEXICO.—A specimen of the desert or eared shrew, *Notiosorex crawfordi crawfordi* was trapped about eleven miles southeast of Las Vegas, San Miguel County, New Mexico in October 1952. Five previous records are known from the state (see Bailey, N. Am. Fauna 53: 369, 1931, from Lincoln and Valencia Counties; Blair, Am. Midl. Nat. 26: 219, 1947, from Otero County (Jones, Southwestern Nat. 4: 111, 1950, from Eddy County).

This record is significant because it extends the northern limit about 140 miles, and the altitude limit to 6,300 feet. Furthermore, the habitat preference of this wide ranging but rarely collected shrew is not well known. The specimen was collected at the base of a west-facing, vertical cliff about fifty feet high. A steep vegetated talus extends about one hundred yards to the floor of the canyon in which a small but permanent stream flows. The vegetation may be classified as postclimax *Pinus ponderosa*, not contiguous with like vegetation normally found at a slightly higher elevation in the nearby mountains. Above the rimrock, the trees thin out in narrow belts of *Pinus edulis*, and *Juniperus monosperma-Quercus undulata* to typical *Bouteloua gracilis* grassland. Rainfall is about 18 inches yearly and the mean temperature is 50°F. One must conclude from these observations and published records that *Notiosorex* can be expected anywhere in the state up to an elevation of 6500 feet.

The specimen, skin and skull, is No. 74 in my personal collection. Its measurements in m.m. are: TL 83.5; Tail 31; HF 10.5; Skull, condylobasal 15.6; broadest (mastoid) width 8.1; interorbital 3.8; palatal length 6.5; weight 3.4 grams.—*Robert G. Lindeborg, N.M. Highlands University, Las Vegas, New Mexico.*

ERRATA

Vol. 4, no. 4, p. 185. (In "Annotated Check List of the Cladocera and Copepoda of Lyon County, Kansas by Carl W. Prophet, Ted. F. Andrews, and Clyde E. Goulden) line 6 in abstract should have read *Chydorus sphaericus* (O.F.M.) was the most frequently collected Cladocera and *Cyclops vernalis* Fischer the most frequently collected Copepod.

INFORMATION FOR CONTRIBUTORS

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